ENVS 401B: ENVIRONMENTAL STUDIES SENIOR SEMINAR

Stormwater Solutions:

Addressing Stormwater Runoff and Phosphorus Loading to Lake Champlain

Middlebury College

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Introduction

Pollutants in the Lake

Lake Champlain is a recreational and aesthetic asset to Vermont, a state that relies on tourism for a large portion of its yearly revenue. A 2008 study reports that, "in 2005, visitors made an estimated 13.4 million trips to the state, spending $1.57 billion" (Dunbar, 2008). Native Vermonters and visitors alike enjoy the lake in all seasons. From water sports like boating, fishing, and swimming, to water supply and transportation, the lake serves many needs. Yet the lake is in danger. With plant and animal health in decline, and beach closure warning signs popping up along its shores, the state of Lake Champlain is coming to the fore as an environmental issue that must be addressed.

When it rains, phosphorus runs off of agricultural land and urban surfaces into rivers and tributaries of Lake Champlain as well as the lake itself. Phosphorus is a nutrient essential for plant growth. It is used in fertilizers, and found in manure, as well as in human and animal waste. However, an abundance of nutrients causes phytoplankton to grow and reproduce rapidly, resulting in algal blooms. Additional plant growth blocks sunlight from reaching deep into the lake and the decay process absorbs dissolved oxygen. Low levels of oxygen and minimal light create a difficult living environment for fish and other aquatic animals. In extreme cases, outbreaks of blue-green algae (cyanobacteria) produce neurotoxins that are harmful to plants and animals and affect the entire food chain if consumed. By essentially fertilizing the lake, phosphorus runoff is throwing off the balance in this delicate ecosystem.

Phosphorus has traditionally been linked to farming practices because manure and other fertilizers are known carriers of the nutrient. However, in recent years scientists have begun to examine the impact of other land use types on phosphorus loading. In the Lake Champlain Basin Program's 2008

State of the Lake Report, scientists estimated phosphorus loads from three different land use types and identified urban landscapes as a major source of this and other pollutants. Their study looked at forested land, agricultural land, and urban/developed land across the state. Their conclusions support a shift in focus from agriculture to urban land. The report concludes that, "on an acre for acre basis, developed land contributes up to four times more phosphorus than agricultural land and seven times more than forests" (State of the Lake, 2008). This statistic encourages state agencies and regulators to shift their focus away from large farms alone, with regard to excess runoff. At the same time, it persuades town planners and developers to reexamine construction projects, city drainage, and other urban infrastructure. The study also notes vast differences in phosphorus contribution by county. In urbanized areas like Chittenden County, which contains Burlington and South Burlington, developed land is the main issue. However, in the Northeast Kingdom where towns are dwarfed by sprawling farms and forests, the betterment of agriculture practices takes priority.

Pathogen contamination from runoff is the leading danger to human health in water-borne environments (Dunbar, 2008). In response to widespread public health concerns, the Lake Champlain Basin Program developed a system of rating beaches based on their closures each year. A good beach is one that is closed between 0 and 2 days each year, fair is 3 to 7 days, and poor is 8 or more days (Dunbar, 2008). In 2006 and 2007, beaches on the Northeastern arm of Lake Champlain were rated as fair, while Mississquoi Bay earned a poor rating (Dunbar, 2008). The remaining sections of the lake are not marked by red flags, yet there is concern about pathogen exposure to swimmers in untested areas.

As a major source of economic and cultural pride falls into disrepair, scientists and policy makers have identified a Total Maximum Daily Load (TMDL) for phosphorus as the primary framework through which to address the lake's decline. A TMDL measures how much of a given pollutant a

waterway can handle before it is deemed 'polluted'. The EPA, under Section 303(d) of the Clean Water Act, requires states to develop TMDLs for targeted pollutants in order to identify impaired water bodies. Since 2001, the Department of Environmental Conservation has been developing TMDLs for Vermont's waterways, covering phosphorus and other pollutants. Since stormwater contributes significantly to phosphorus loads in Lake Champlain, controlling this source will be essential to meeting these TMDL standards and repairing watershed health in Vermont.

Stormwater

Stormwater runoff is defined as any precipitation from rain or snowmelt that flows over land without percolating into the ground and is eventually discharged into streams, rivers, lakes, or coastal water bodies (EPA, 2011). Between first touching the ground and reaching its stream discharge point, stormwater accumulates sediment, nutrients, and chemicals from the surfaces over which it flows. Eventually, these substances become incorporated in major water bodies and contribute to water pollution and degradation. Thus, stormwater runoff intimately connects the characteristics of land surfaces to water quality.

Depending on what land use types it travels through, stormwater runoff may be categorized as either point source or nonpoint source. The definition of point source pollution, which originally described sewage and industrial wastewater discharges, has expanded to include stormwater runoff from industrial and construction sites. These point sources are relatively easy to regulate and treat since they are produced in, and discharged from, a single point, such as a treatment plant. As a result, large factories and other commercial areas regulated by the EPA no longer pose a significant threat to surface water. On the other hand, nonpoint sources, including runoff from agricultural and municipal land, discharge the majority of stormwater runoff and contribute 90% of damaging water pollution nationally (Huang et al., 2007). Nonpoint source runoff flows from a diffuse area and

enters waterways either at a single discharge site or at many points along the water body. Consequently, this type of runoff is much more difficult to monitor, regulate, and control. For example, the EPA originally designed the National Pollutant Discharge Elimination System (NPDES) to solely permit point sources based on compliance with criteria for maximum pollutants allowed in water discharges (TMDLs). This program resulted in drastic improvements in the quality of water exiting industrial and construction sites. However, the EPA's efforts to regulate nonpoint sources were far less successful. First, in order to identify nonpoint sources, the EPA delineated municipal separate storm sewer systems (MS4s), or publicly owned conveyance systems for directing stormwater from developed areas into water bodies. MS4s could be on the scale of states or villages, and they were the first step toward defining responsible parties for nonpoint source runoff. Meanwhile, the EPA and other regulatory organizations have put pressure on individual farm owners to develop better practices for reducing the contamination from agricultural stormwater runoff and the amount of discharge into water bodies. Unfortunately, compliance with these demands and actual water quality improvements have remained elusive for nonpoint sources from developed and agricultural lands, not to mention the many small-scale areas that are not included under any water quality jurisdiction.

The difficulty of regulating nonpoint sources raises the question as to where EPA's limited resources might be best directed to maximize pollution reduction. Urban and agricultural land uses affect stormwater pollution in different ways. The high amounts of phosphorus- and nitrogen-containing fertilizers used on crops and pastures, as well as nutrients and bacteria in animal feces, are responsible for the majority of pollutants found in agricultural runoff. On the other hand, fertilization of lawns, leaching and corrosion from exposed materials, inappropriate waste discharges, and exhaust emissions and leaks from vehicles impact pollutant loading in urban runoff. Recent research suggests that statewide, agriculture and urban areas are almost equally responsible

for degradation of Lake Champlain, contributing 38% and 46% of phosphorus runoff, respectively (State of the Lake, 2008). Thus, both land use types must be dealt with in order to attain the TMDLs for phosphorus in the Lake.

Agricultural stormwater runoff in Vermont has traditionally been perceived as the greatest nonpoint source threat to water quality (Budd and Meals, 1994). In this state especially, the agricultural sector comprises the majority of land use and is responsible for a large part of statewide economic profits, while the farmers themselves struggle with lower earnings and higher poverty rates than their urban counterparts (Economic Research Service, 2011). This social dynamic complicates agricultural runoff regulation, since farm owners are often financially incapable of fulfilling the recommendations and demands of water quality officials. Thus, blame on the agricultural sector for phosphorus loading into Lake Champlain and rumors of regulation on the horizon have created a tense political atmosphere. Many farmers remain frustrated that municipalities which they see—correctly—as significant contributors to phosphorus loading, face little regulation with regard to water quality.

Partially as an outcome of this and similar debates, state agencies, municipalities, and citizens have turned their attention to impervious surface created by urbanization and land development, with a new focus on regulation and management. Impervious surface is any surface, including natural stone and man-made asphalt, which is impermeable to water. In general, impervious surface decreases the ability of stormwater to penetrate the ground, leading to an increased volume of stormwater discharge into water bodies and erosion of surrounding lands as well as an increased concentration of pollutants stripped from these impermeable materials during storm events and carried downstream by runoff. Extensive research now suggests that there is a direct correlation between percent impervious surface in a watershed and negative impacts on downstream biological

conditions (National Research Council, 2008; Groffman et al., 2004; National Stormwater Quality Database; Pitt et al., 2004). In particular, the intensity with which polluted stormwater flows into streams not only pollutes the water but drastically alters streambed structure and hydrology and destroys benthic ecosystems (Pratt et al., 1981). With ever-increasing urbanization throughout the US, the impact of developed land on water quality is bound to intensify in the coming years, and Lake Champlain will become only one in a multitude of damaged water bodies (EPA, 2001).

A Brief History of Water Treatment and Management

Water protection developed slowly in the United States. Most cities did not have municipal sewage systems until the late 19th century, with smaller towns lagging even further behind (Melosi, 1999). Spurred by cholera and dysentery epidemics, cities eventually built sewer systems that pumped waste water directly into streams, rivers, and other water bodies to move the dangerous waste away from population centers. Techniques for filtering sewage have existed since the end of the 1800s, but they were largely disregarded until the middle of the 1900s. In 1880 only 0.35 percent of the U.S. urban population had treated sewage. By 1920 that number had increased to 17.5% of the urban population. In 1972, the Environmental Protection Agency (EPA) enacted the National Pollutant Discharge Elimination System (NPDES) under the Clean Water Act which finally mandated that municipalities treat their wastewater before releasing it into natural water bodies. Since then, wastewater treatment plants have become increasingly common, but the problem of nutrient pollution has not been resolved.

Stormwater has traditionally been dealt with in two ways in urban areas. First, runoff may be collected from impervious surfaces and channeled into a combined sewer system (CSS), where it is treated along with municipal waste (Melosi, 1999). Although this system treats stormwater to some extent, it is prone to combined sewer overflows (CSO). A CSS will often become inundated with

water during a severe rain event, forcing the plant to release untreated waste and water directly into the environment. These overflows dump large amounts of phosphorus, nitrogen, and other harmful pollutants into streams and rivers. Alternately, runoff may be collected from impervious surfaces and transmitted via a separate storm sewer system directly into a body of water to be removed from the urban area (Melosi, 1999). Separate sewer systems are beneficial in that they avoid the problem of frequent CSO events during severe storms. However, separate sewer systems release largely untreated stormwater into natural waterways. On top of that, sewage overflows may still occur due to aging or inadequate infrastructure. The Town of Middlebury, with separate sewer systems, experienced a sewage overflow during the extreme weather of Tropical Storm Irene and was forced to release untreated waste into Otter Creek (Bob Wells, personal communication). Extreme weather occurrences still overwhelm many waste water treatment facilities and also increase pollution via urban runoff.

Current Stormwater Management in Vermont

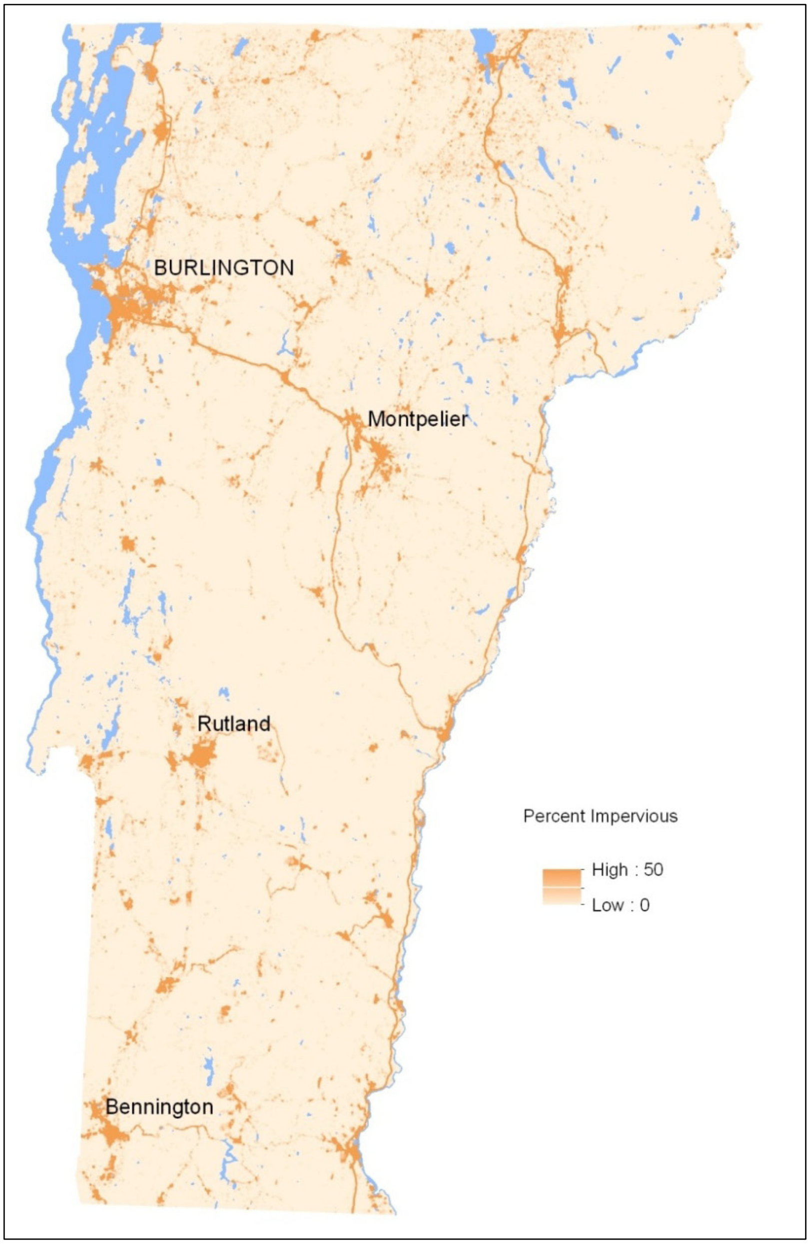

Figure 1. Impervious land cover was estimated based on land use and population density data. The majority of Vermont's impervious land is found in and around cities. We estimate that Vermont has 137.7 km^2 of impervious surface, making up 0.55% of the State's total area. We also estimate that land for commercial, industrial, and transportation uses represents the majority (64.3%) of all impervious land.

Note that rural and forested land was not included in the analysis; we focused primarily on stormwater from developed areas.

Please see the Appendix on page 14 for more information on how impervious surfaces were estimated.

Pct. of impervious area by land use	**Total (km^2)**	**Pct. of total**
Low Intensity Residential	27.5	20.0%
High Intensity Residential	13.1	9.5%
Commercial/Industrial/Transportation	88.5	64.3%
Quarries/Strip Mines/Gravel Pits	1.3	0.9%
Urban/Recreational Grasses	7.3	5.3%
Total	**137.7**	100.0%

Vermont's stormwater regulations currently address stormwater management in new developments, but not on existing developed land. Both Act 250 and the Water Quality Treatment Standards (WQTS) require new developments to apply for permits that ensure proper stormwater management. Act 250 is Vermont's blanket environmental legislation for construction and development projects (Sanford and Hubert, 2000). It does not specifically regulate projects, but does require that any new development above 2500' elevation and development on one acre or more of land "will not cause unreasonable soil erosion or reduction in the capacity of the land to hold water so that a dangerous or unhealthy condition may result" (Act 250). Under Vermont's WQTS, new construction projects that add more than one acre of impervious surface to a site must capture 90% of annual storm events and remove 40% of the total phosphorus load in runoff (VTANR, 2002). However, neither addresses pollution from runoff on sites that are already developed. Existing sites are only required to reduce impervious surfaces by 20% or treat 20% of their stormwater during redevelopment (VTANR, 2002). Stormwater management in towns and villages is left largely to local officials and is not under national or statewide guidelines. As a result, most town plans do not address stormwater comprehensively, if at all. Countywide Regional Planning Commissions offer technical and planning assistance for more effective stormwater management, but do not have the authority or means to implement these projects without the support of local or state governments. Thus, Vermont requires a more comprehensive, integrative, and structured stormwater program in order to mobilize its citizens and governments, mitigate stormwater runoff, and restore the health of its water bodies.

Implementing such a program has faced and will continue to face many obstacles. This report seeks to address some of these stormwater management challenges in Vermont at local and statewide levels. Chapters 1-3 examine scientific, technological, and financial aspects of stormwater

management and present recommendations to the Town of Middlebury, the Vermont Department of Environmental Conservation, and the state legislature for effectively dealing with stormwater.

Stormwater Monitoring Program for Middlebury, Vermont

Community Partner: Fred Dunnington, Town of Middlebury, Town Planner

Chapter 1 presents recommendations for—and evidence for the feasibility of—a stormwater monitoring program for the Town of Middlebury. Monitoring of stormwater runoff from urbanized areas is critical for identifying and managing the sub-watersheds contributing to water quality degradation in streams, rivers, and lakes. In the US, however, the majority of stormwater monitoring has focused on large watersheds and major cities, whereas monitoring in small towns is practically nonexistent due to lack of funding and support. Furthermore, in Vermont, water quality monitoring has taken place largely within streams. While these data may reveal the contribution of larger watersheds to water quality in main bodies of water such as Lake Champlain, they cannot differentiate between the urban and agricultural sub-watersheds within larger drainage areas which may exhibit very different stormwater runoff characteristics. Thus, our stormwater sampling scheme pinpointed small, localized sub-watersheds within the Town of Middlebury in order to characterize the effect of small-town development on stream water quality. The project consists of an ideal stormwater monitoring plan that can be implemented by the town in the future to fully characterize Middlebury's stormwater runoff, as well as a preliminary analysis of water quality from runoff in two sites in downtown Middlebury. This analysis was used to validate the practicality of the sampling process as well as suggest improvements to the methods.

Low Impact Development: Putting the LID on Stormwater

Community Partner: Jenna Calvi, VT Dept. of Environmental Conservation, Stormwater Division, LID Project

Chapter 2 presents an overview of the benefits, challenges, and successes of Low Impact Development (LID) practices for stormwater management in Vermont. LID involves designing buildings, infrastructure, and landscapes to restore natural hydrological function, minimize impervious surfaces, and maximize natural absorption and filtration of stormwater (EPA, 2007). LID stormwater management systems are often less expensive to build and maintain than their conventional counterparts, and therefore represent a cost-effective approach to minimizing water pollution (EPA, 2007; UNH Stormwater Center et al., 2011). Despite LID's promise, several barriers impede its widespread application: lack of public and professional education about stormwater management and LID practices; lack of consistent funding for LID projects; and a complicated and inconsistent set of regulations regarding LID projects throughout the state. We recommend programs to overcome each of these barriers in Vermont, and finish our report with a resource guide to assist individuals and businesses in implementing LID projects.

Vermont Runoff Management Utility

Community Partner: Julie Moore, Stone Environmental, Water Resources Management, Group Leader

Chapter 3 presents a proposal for a statewide runoff management utility in Vermont. It refers to a structure that manages stormwater mitigation initiatives, funded by a dedicated recurring fee charged to residents. Two stormwater utilities already exist in Vermont. Both systems have made progress toward improving the health of Lake Champlain through mitigation of nonpoint sources of pollution including urban stormwater runoff. Yet outside of the state's most urbanized areas, the approach to stormwater management has largely been piecemeal. Small towns lack dedicated technical expertise and budgets to plan or implement large projects. The success of urban programs

contrasted with the limitations faced by smaller communities forces the consideration of a larger, more comprehensive utility across the state. The utility will promote awareness of runoff issues, while funding programs that consider the state as a whole to focus funds and expertise on crucial areas. Every dollar invested will ideally be maximized by the economies of scale, while the model's structure is based on an evaluation of current, smaller-scale models, existing state utilities, and cost effectiveness. Ultimately, this proposal focuses on the structure and funding of the utility rather than political nuances associated with its adoption.

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Appendix

The GIS map displayed on page 8 estimates impervious surface percentages based on land use and population density data. These estimates are made using information from Prisloe et al. 2003. This study used remote sensing data to determine accurately where impervious surface was located, and then related these data to land use and population density data. The result is a chart that estimates the proportion of impervious surface for any plot of land based on its land use and population density. It should be noted that these coefficients were estimated from towns in Connecticut and that proportions in Vermont are likely different based on different land use patterns. Also, land use terminologies differed slightly between the Prisloe et al. study and the Vermont land use data, requiring some modification.

Land use data was taken from the National Land Cover Database 2001. Impervious surfaces in rural areas, forests, and wetlands were estimated to be negligible, since our statewide utility focuses primarily on urban runoff from developed areas. As such, impervious surface coefficients for the following land uses were rounded to zero: open water, bare rock/sand/clay, transitional, deciduous forest, evergreen forest, mixed forest, shrubland, orchards/vineyards, pasture/hay, row crops, small grains, woody wetlands, and emergent herbaceous wetlands.

The Focal Statistics tool was used to smooth the data to make impervious areas more easily visible.

Because of the age of the data, the uncertainty of the accuracy of the coefficients used, and the omission of rural areas, forests, and wetlands, these data should be considered no more than rough estimates. Remote sensing or on-site measurement would provide a much more accurate estimate of percent impervious surface cover. However, for a quick, statewide estimate of impervious surface cover, we feel that this is a reasonably accurate method.

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Chapter 1 Stormwater Monitoring

Bianca Dragone, Alyssa Kronen, Sunny Ng, Alison Siegel

1.1 Introduction

Traditionally, urban areas have been designed to efficiently channel stormwater from precipitation away from densely populated areas and directly into larger water bodies to avoid human contact and structural damage. Impervious surfaces such as concrete and asphalt facilitate that goal by allowing runoff to move swiftly into drains and via pipe into rivers and lakes. However, those hard surfaces also inhibit the natural percolation of stormwater into the ground and instead channel higher volumes of water into local waterways. Only recently have scientists begun to recognize that impervious surfaces are a significant source of pollution because they deliver large, rapidly flowing volumes of contaminated stormwater to water bodies. New architecture seeks to shift from this longstanding approach towards more sustainable solutions that promote containment, storage, and use of water within the developed landscape. Problems relating to stormwater still need to be addressed in areas where these new designs have not been successfully implemented.

However, without concrete data about the types and concentrations of pollutants running off from different areas, it is nearly impossible to enact legislation or propose best management practices (BMPs) to reduce stormwater runoff and to improve water quality. Thus, identifying pollutants in stormwater runoff from urbanized areas is a critical step in the management and conservation of water quality in the U.S. and Vermont.

Previously, this task has been tackled through short- and long-term monitoring programs that sample water quality in various settings in order to determine potential sources of pollution and the

extent of water quality degradation in a particular area. In the past 10 years, the National Stormwater Quality Database (NSQD) has compiled monitoring data from Municipal Separate Storm Sewer Systems (MS4s) for nearly 8,000 individual storm events. However, this dataset contains several important gaps. The protocol for MS4 monitoring is not explicitly established by the EPA and is thus left at the discretion of the permitting authority (National Resource Council, 2008). This legislative loophole could result in data points that cannot be correlated due to high variability in the methods. Secondly, the NSQD is not representative of all permitted MS4s, as many are simply not monitored. This is primarily due to lack of EPA regulation. However, even the sites that have been monitored generate relatively few data points (about 15 points over five years), and comparison across these sites is difficult due to variation in climate, precipitation, geology, and other environmental factors. Lastly, the majority of these data points involve drainage from large watersheds which range between thousands of hectares and include various land-use types. This type of monitoring obscures the relationship between urbanization and stormwater quality as well as neglects the effect of smaller municipalities on statewide and national water quality.

Most small municipalities, including Middlebury, are not included in any MS4 and have no explicit stormwater quality parameters (Ethan Swift and Tim Clear, personal communication). Overlooking these communities discounts possible sources of pollution and excludes a significant portion of the population from involvement in water quality improvement efforts. The public consequently has little knowledge or interest in this prominent environmental issue.

Understanding the differences in pollution contribution between small municipalities and agricultural lands is critical for reducing pollutant loads and garnering support for more efficient management practices for stormwater in rural Vermont. Currently, the majority of monitoring in Addison County occurs in rivers and is conducted through the Addison County River Watch

Collaborative (ACRWC). This group samples rivers to monitor the long-term effects of land-use change on water quality. The state's Illicit Discharge Detection and Elimination (IDDE) program works to preserve water quality by identify leaks in sewer and stormwater pipes that may be contributing to water pollution.[1] Neither of these projects, however, addresses the specific relationship between impervious surface in localized urban and mixed urban and rural areas on pollutant levels in stormwater runoff. This connection is critical to allow towns like Middlebury to endorse and design effective low impact development (LID, outlined in Chapter 2) and Best Management Practices (BMPs) based on detailed knowledge about the specific locations most responsible for water quality degradation. LID is infrastructure designed to retain and reuse water on site and tries to imitate natural ecosystems by allowing water to percolate through vegetated pervious surfaces.

Middlebury is situated amidst a robust network of rivers and is thus a prime candidate for pilot stormwater sampling projects. The Town straddles Otter Creek, a direct tributary of Lake Champlain (Figure 1.1). Thus, many pollutants such as phosphorus wash into Otter Creek and contribute to algae blooms and ecological degradation of Lake Champlain. Every year, Otter Creek contributes 123.3 tons of phosphorus, or 32% of total phosphorus loads, to Lake Champlain (Lake Champlain Basin Program, 2008). Stormwater runoff from both urban and agricultural land in Middlebury is a major source of these contaminants (Huang et al., 2007). Because reductions in agricultural runoff have been slow to develop due to political and economic factors, knowledge of how urban environments contribute to river pollution is essential to address water quality issues in Lake Champlain and Vermont as a whole.

[1] http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=min_measure&min_measure_id=3

In collaboration with Middlebury Town Planner Fred Dunnington and other community members, we embarked on a stormwater assessment project to help identify and characterize pollutant loads from the town's runoff. We created a sampling procedure that allows small towns like Middlebury to measure pollutant levels in stormwater runoff from specific areas and determine how different land use types impact these pollutant levels. Our hope is that town officials, including Mr. Dunnington, can use this information to pursue new management projects to mitigate pollutant runoff during storm events. Furthermore, in order to validate and exemplify the practical use of this procedure, we performed preliminary sampling and analysis of stormwater runoff from two sites within the commercial section of Middlebury. In this chapter, we propose our ideal monitoring program and discuss the results from our initial water sampling analysis. A stormwater monitoring program in Middlebury would not only provide information about non-point sources of pollution but would also reconnect the community to their watershed and encourage members to get involved in sampling, research, and future planning.

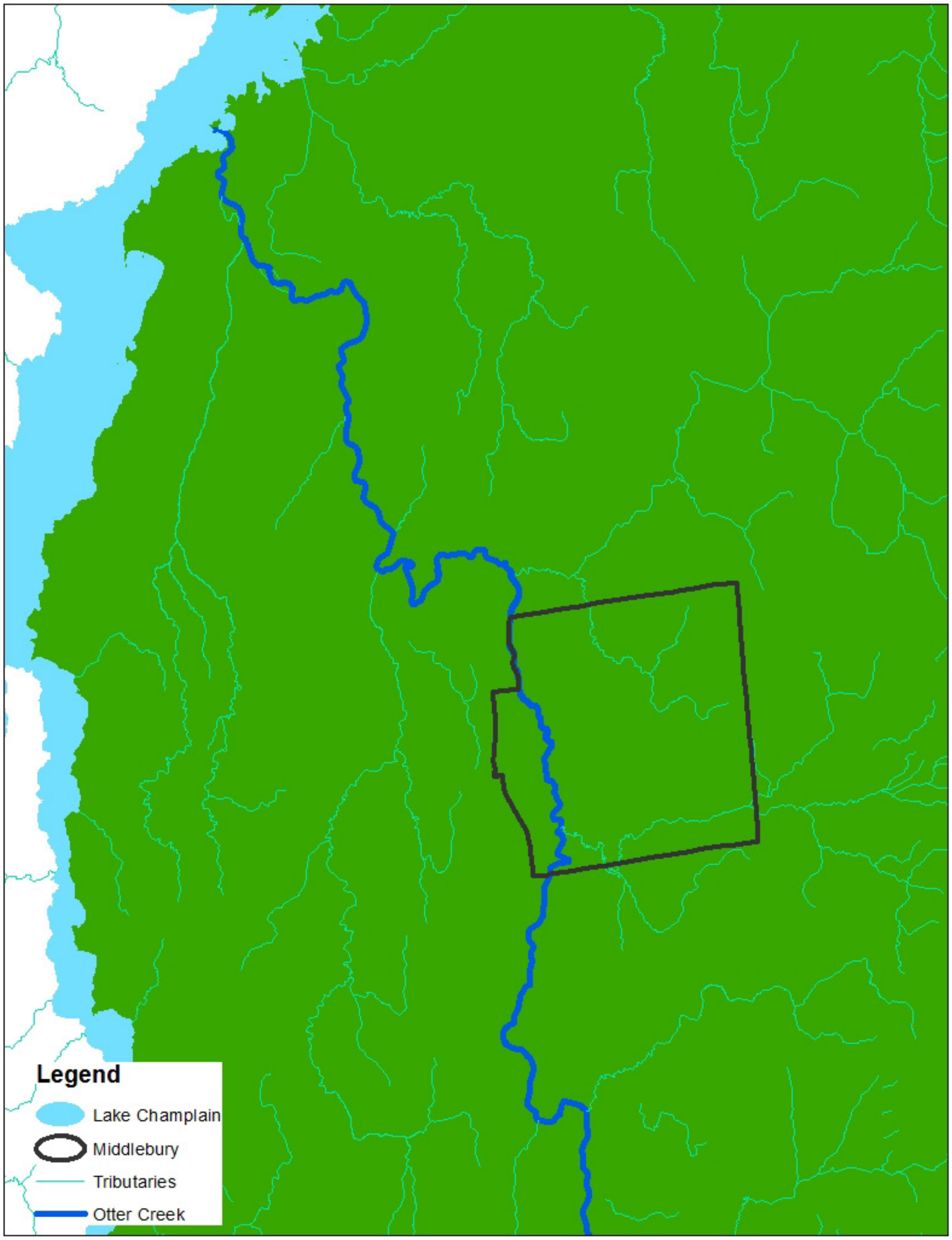

Figure 1.1. Location of the Town of Middlebury and Otter Creek in relation to Lake Champlain.

1.2 Ideal Monitoring Plan

Stormwater monitoring programs must consider the appropriate methodology, sampling location, and number of samples. It is crucial to find the sampling scheme that will give the best results given the available resources. Any town, municipality, or other monitoring group must decide how to sample, where to sample, and what to analyze for based on their individual needs, interests and budgets. Considerations must include access to laboratories for analyses and the number of people required to collect samples.

1.2.1 Sample Collection Methods

According to Lee et al. (2007), variability is the most important factor to overcome in designing and implementing any stormwater monitoring program. The sample collection technique, as well as the timing of the sampling and the number of samples, has important implications for variability. There are two main ways to collect samples: grab sampling and automatic sampling. Samples from the same storm event are often composited—or combined—based on either the time they were taken (time-based) or the flow of the water when they were taken (flow-weighted). The way the samples are composited impacts their accuracy and variability (National Research Council, 2008). Once the samples are analyzed, the flow data can be used to calculate the Event Mean Concentration (EMC) for each parameter that is tested.

Grab sampling requires collecting discrete samples from an outfall point within a short period of time, usually 15 minutes (Lee et al., 2007). It involves relatively little in terms of equipment aside from sterilized containers suitable for trace analysis. Although grab sampling is often seen as the easiest sample collection method, it can also be labor-intensive and have very high variability. Lee and Stenstrom (2005) explain that grab samples have more outliers, or pollutant concentrations that fall outside of the range of the rest of the data, than composite samples. Compositing and averaging

single grab samples also leads to erroneous results (Lee et al., 2007). These errors are largely due to the impact of time in the storm event on pollution concentrations. Thus, more samples taken throughout the storm event should reduce errors. In order to reduce the inaccuracies and bias inherent to grab sampling at least twelve samples should be taken for each storm event (Leecaster et al., 2002; Lee et al., 2007). Additionally, the intensity of the storm can affect the flow rate and impact the concentration of pollutants in the sample. Teams must be properly trained to grab samples to minimize these errors (Lee and Stenstrom, 2005).

Automatic samplers reduce many of the time- and flow-related errors associated with grab samples. An instrument is installed at the sample point and collects a specific volume of stormwater at regular time intervals. It can operate on its own, freeing analysts to focus on other parts of the study (Lee and Stenstrom, 2005). Certain models also collect information about the flow rate. This enables samples to be composited either by time or weighted by stormwater flow. However, automatic samplers require expensive instrumentation that must be installed properly before it can collect samples (Lee and Stenstrom, 2005). For municipalities or small groups, they may be beyond the monitoring budget, or there may not be someone with the proper training to install them. Although we do not specifically recommend in subsequent sections that towns measure these parameters, it is worth mention that automatic samplers are not suitable for measuring oil and gas (O&G) and indicator bacteria (Lee and Stenstrom, 2005). In implementing a stormwater monitoring program with limited resources, it is better to place automatic samplers at a representative subset of sampling points, and to collect grab samples from the rest (Lee et al., 2007; Lee and Stenstrom, 2005). This monitoring program will provide comprehensive data for a few specific sites rather than highly variable data from many different sites.

Many studies have demonstrated the "first flush" effect, in which a higher concentration of pollutants is found in runoff from early in a storm event because built-up pollutants can be washed away easily (Lee and Stenstrom, 2005; Lee et al., 2007; Maestre et al., 2004; National Research Council, 2008). Therefore, samples taken early on in a storm event overestimate the pollutant concentration in runoff, whereas those taken later on miss the first flush. Maestre, Pitt, and Williamson (2004) compared 417 paired samples of grab samples taken during the first 30 minutes of the storm and flow-weighted composite samples from the National Pollutant Discharge Elimination System (NPDES) MS4 database. They found the median of the first flush dataset was significantly different from the flow weighted composite samples for 55% of the cases analyzed. They concluded that first flush effects are most common in small, paved areas with simple drainage systems during events of steady rain.

Furthermore, certain areas are more likely to exhibit a first flush and variation in pollutant concentrations based on land use type (National Research Council, 2008). In some circumstances maximum pollutant concentrations in runoff occur with the most intense rainfall. As a result, it is important to determine the most appropriate time to collect samples based on the climatic conditions of the sample site, its size and composition, and the pollutants being analyzed. In places with a distinct rainy and dry season, there may be a seasonal first flush as a rain event washes away months' worth of pollutants that have built up on surfaces (Lee et al., 2007). Therefore, it is important to collect samples from various times throughout the season. In areas where seasonal first flush is an issue, samples should be collected throughout the entire rainy season.

In addition to the timing of the sample collection, the choice between discrete and composite samples has implications for the accuracy of the method. Discrete samples are taken at regular time intervals, often every 15 to 20 minutes, and analyzed separately (National Research Council, 2008).

This method is time and resource intensive, but it gives a picture of the changes in pollutants over the entire storm event. In time-based composite sampling, equal weight is assigned to all parts of the storm, but the sample size is large enough to give a relatively accurate reading of the pollutant concentration in the storm's runoff. Flow-weighted composite sampling requires the combining of samples based on the volume of runoff. More samples represent the peak flow of the storm when they are composited. Scientists agree that flow-weighted composite samples provide the most accurate representation of pollutant concentrations in stormwater runoff as defined by how closely they measure EMCs (Lee et al., 2007; Lee and Stenstrom, 2005; National Research Council, 2008).

1.2.2 Choosing Stormwater Sampling Sites

Developing a good sampling scheme requires choosing sampling sites that provide an accurate representation of sub-drainage basins. Sub-drainage basins are areas that collect water which is released through a single stormwater outfall pipe. However, to determine more finite relationships between pollutant loads and land use type, a combination of sampling sites must be chosen for a comparative study (Lee and Stenstrom, 2005). Research from the Michigan Department of Environmental Quality shows that concentrations of total phosphorus (TP) vary for different land use types. From highest to lowest, the general trends for TP concentrations by land use type are low/medium density residential areas, highways, agriculture/pasture, commercial, industrial, high density residential, forest/rural/open space, and water/wetlands (Michigan Department of Environmental Quality, 2009). Numerous combinations of land use types can be chosen. A study can compare different land use types, similar land use types with and without Low Impact Development, and similar land use types with different development uses such as two different industries. Table 1.1 summarizes the variables that must be considered for selecting sampling sites for a comparative study.

Table 1.1. Variables that must be considered when selecting sampling sites.

Variable	Characteristics
Unique Sub-Drainage Basin	Outfall points for sampling must drain different sub-drainage basins
Land Use Type	Land use types will be similar or different depending on the goal of the comparative study
Land Use Specifics	Types of agriculture or industries should be considered
Topography	Sites should have similar slope gradients
Soil Type	Sites should have similar soil profiles

Sampling sites can be chosen to compare different land use types by using these anticipated relationships. Sites comprised of various land uses must be chosen from unique sub-drainage basins and controlled for other variables such as topography and soil or bedrock type. These parameters affect which natural substances are dissolved in stormwater and change the way water flows over or percolates into the land. Clay soils, for example, are highly saturated and therefore impermeable, having little capacity for water absorption and retention. This characteristic is especially influential in stormwater flow in the Lake Champlain Basin, where there is a high proportion of clay soil. Different soil types may contain varying levels of metals ultimately influencing pollutant runoff into water bodies (Dong et al., 1983). In addition to soil type, the topography of the land influences the rate of water flow as well as the amount of sediment erosion and sediment deposition into water bodies. Although varying land uses, soil composition, and topography are highly varied even across a small landscape and therefore difficult to control for, we recommend that towns find sampling sites with similar characteristics.

A comparative study can be conducted on similar land use types with varying levels of impervious cover. For example, two sites that are 75% industrial may have different concentrations and types of pollutants depending on their operations (Lee and Stenstrom, 2005). Similarly, small urban areas

contribute different levels of pollutants to stormwater due to the types of impervious surfaces present. A study concerning an urban area in Wisconsin found that roof runoff had the highest concentration of zinc, while street runoff contained high concentrations of cadmium and lead (Pitt et al., 2004).

The distribution of land use types and any existing stormwater treatments across the sub-drainage basin is another important factor in identifying sample sites. Individual sub-drainage basins may have varying types of infrastructure such as LID swales, gutters, or traditional curbs, different ages of infrastructure, and different levels of maintenance of best management practices (Michigan DEQ and Law, 2008). A 75% impervious surface area, for example, may include LID features which buffer storm drains and reduce stormwater runoff. On the other hand, an area with 25% impervious surface may be composed of high gradient slopes and grass fields instead of LID features. The composition of other characteristics of each sub-drainage basin should be considered to better inform hypotheses on the relationship between pollution load and land use type.

An example of a comparative study of a treated and untreated sub-basin would be choosing basins with and without LID infrastructure yet with similar percentages of impervious surface. Dietz and Clausen (2008) compared two housing developments that were similar in size, one of which was constructed using LID techniques. They analyzed stormwater runoff as the two developments were constructed and compared how the volume and pollution levels changed. The results of this study indicated that LID techniques on a watershed scale can reduce concentration of stormwater pollutants by two orders of magnitude. This comparative study can help identify the impact of stormwater treatment strategies in reducing stormwater volume and pollution.

The next step following determination of areas to compare is to select specific discharge points using maps of stormwater drains and outfalls. Maps and blueprints of stormwater infrastructure can

be obtained from the town's public works personnel. Discharge points should have similarly sized sub-drainage basins to ensure that each receives an equal amount of rain. This consideration is based on the assumption that rainfall is consistent throughout space. Another option is to select different sized drainage basins and calculate concentration of pollutants per unit area at the end of the analysis. Sub-drainage basins can be determined and mapped using the stormwater infrastructure maps and information about the direction of stormwater flow over surface and through storm pipes. Thus, there are two considerations for choosing comparable sampling sites: (1) basins must have similar areas or, if this is not possible, area must be canceled out in the final pollutant concentration calculations and (2) they must be in close proximity to each other to ensure similar rates of precipitation and for samples to be collected within a short time frame of the same precipitation event (Hannerz, 2006).

One approach to mapping surface water flow within a sub-drainage basin is with a Global Positioning System (GPS). During a heavy rain event, stormwater flow can be mapped in the field using GPS units by observing the water's path into a sub-drainage outfall. Therefore, the best time to conduct this method is during heavy precipitation events when surface water flow can most easily be identified. Another option is to use a Geographical Information System (GIS) analysis of Light Detection and Ranging (LiDAR) digital elevation models. Like GPS, LiDAR uses satellite technology, but differs in that it sends and receives many tiny pulses to create high-resolution elevation data. LiDAR images contain detailed information about earth's surface and can be used to map sub-drainage basins. However, it is important to field check LiDAR images because minute changes in topography, such as fractures on sidewalks, or changes in the developed landscape since the LiDAR images were taken may alter the accuracy of the estimated size of a drainage basin (Nelson, 2006). Field checking with a GPS unit allows for more accurate catchment boundaries to

be defined. Once the sub-drainage basin of an outfall point is measured, the origins of the stormwater pollution from the outfall point can be determined.

1.2.3 Parameters for Analysis

Phosphorus

Stormwater runoff is highly correlated with increased phosphorus levels in lakes and freshwater systems (Mallin, 2009). As previously noted, phosphorus loading in the Lake Champlain basin is a problem of mounting concern. While phosphorus is an essential, and often limiting, nutrient required for plant growth, increased levels of phosphorus lead to increased phytoplankton growth and the algae blooms observed in Lake Champlain (Benitz-Nelson, 2000; Correll, 1998). It is important for any monitoring program to measure phosphorus levels in a town's stormwater runoff.

The most commonly measured forms of phosphorus in freshwater environments are total phosphorus (TP) and dissolved phosphorus (DP) (EPA method 365.1). DP is scientifically defined as phosphorus that can be filtered through a filter size of 0.45 microns. These soluble compounds include both organic and inorganic phosphorus. The most commonly found form of inorganic phosphorus is the orthophosphate ion. TP includes both the dissolved phosphorus as well as phosphorus suspended in the water as particles.

Phytoplankton and other bacteria take up dissolved phosphorus through absorption, making it the primary culprit in eutrophication. It is difficult to quantify dissolved phosphorus or observe significant trends as its levels fluctuate regularly (Correll, 1998). Phosphorus in suspended particulate form, on the other hand, tends to settle. As a result it is only introduced into organisms through direct consumption. TP has been found to be in equilibrium with DP; if the concentration of dissolved phosphorus is low the element will be released from the particle to which it is adsorbed

(Correll, 1998). This correlation between particulate phosphorus and dissolved phosphorus makes it necessary to measure both TP and DP to obtain a proper understanding of the overall nutrients in stormwater runoff and how that will influence aquatic ecosystems.

The EPA outlines methods acceptable for measuring phosphorus levels at a stormwater permitting standard. Ideally, towns would implement EPA-recommended procedures for analyzing phosphorus levels in stormwater runoff. The EPA method requires the reaction of the sample with ammonium-molybdate (EPA method 365.1). The product of the reaction between the ammonium-molybdate complex and orthophosphates produces a blue color. Colorimetric analysis is subsequently used to determine the overall concentration of phosphorus. Measuring dissolved phosphorus merely involves filtering samples through a 0.45 micron filter prior to the reaction and colorimetric analysis. The cost associated with the colorimeter and a test kit (good for 100 samples) is $400 – $500 (Hach Instrument Manual). The instrument's expense is justifiable by the fact that it can be used to analyze numerous other parameters. We recommend colorimetric analysis as a simple way to measure phosphorus.

Nitrogen

Nitrogen is another essential nutrient for plants. Major anthropogenic sources include fertilizer, manure, pesticides, and fuel combustion (Schindler et al., 2006). The ratio of total nitrogen to total phosphorus (TN:TP) is a known effective predictor of algal growth nutrient limitations (Guildford and Hecky, 2000). It is important to measure the amount of nitrogen in stormwater runoff to obtain information about this ratio and its influence on potential algal blooms in Lake Champlain. Nitrogen tends to be more readily available then phosphorus in the freshwater environment and consequently is not that ecosystem's limiting nutrient (Guildford and Hecky, 2000). As a result it is not commonly attributed to the Lake's algal blooms like phosphorus is. Regardless, it is important for ecosystem

health to determine the amount of nitrogen entering Lake Champlain through stormwater runoff. While nitrogen is not the limiting nutrient for Lake Champlain, it might be for other freshwater systems, and should therefore be included in stormwater monitoring programs. Additionally, increased concentrations of nitrogen compounds are correlated with aquatic ecosystem acidification - another reason for a town to analyze runoff for nitrogen (Schindler, et al., 2006).

Total Kjedahl Nitrogen (TKN) is a common parameter that is tested for by the EPA under the Clean Water Act (National Research Council, 2008). TKN encompasses all organic nitrogen coming from biological sources and ammonia as opposed to total nitrogen, which includes nitrates and nitrites and is not a set EPA parameter (EPA method 351.1). The process outlined by the EPA to determine TKN is labor intensive. Samples are digested with potassium sulfate and mercuric sulfate, which converts organic nitrogen into ammonium sulfate. The solution is neutralized by sodium hydroxide solution and then reacted with alkaline phenol and sodium hypochlorite to form a blue color. Sodium nitroprusside is added and then the product is analyzed by semi-automated colorimetry in order to measure the levels of nitrogen. Small towns may not be required to monitor based on a strict adherence to EPA approved methods, so while ideal to follow EPA methods, there are other options. Portable colorimeters, for example, provide easy ways to measure nitrates and nitrites, which are not EPA required tests for stormwater runoff, but are still detrimental to ecosystem health.

Heavy Metals Analysis

Heavy metals analysis should also be included as part of an ideal monitoring program. Heavy metals, such as cadmium, copper, chromium, lead, nickel, and zinc are introduced into urban stormwater runoff from building corrosion, automobiles, atmospheric deposition, and certain industrial practices (Lee et al., 2007). Heavy metals do not degrade readily in the natural environment. They are

absorbed faster than they are released, resulting in higher concentrations in organisms higher up the food chain. This leads to high concentrations of heavy metals in food, negatively impacting health as heavy metals are toxic and interfere with organismal development (Herngren et al., 2005). Copper, lead, and zinc are the three most commonly analyzed metals in storm water runoff while cadmium and lead are commonly found in road runoff (National Research Council, 2008, Pitt et al., 2004). However, other metals may be of concern in specific watersheds. For instance, mercury has been identified as a toxin of concern in Lake Champlain (State of the Lake, 2008).

Heavy metals analysis is conducted using a technique known as Graphite Furnace Atomic Absorption Spectrometry (GF-AAS), with the exception of mercury, which is measured using a technique known as Cold Vapor Atomic Fluorescence Spectrometry (EPA methods 200.7 and 200.9). The cost of these instruments is beyond the budget of most small towns and only qualified scientists should perform analyses.

pH

The relationships between heavy metal bioavailability and other parameters such as pH, suspended solids, and dissolved organic carbon (DOC) are well documented (Herngren et al., 2005). The pH, or level of acidity, changes the solubility of a substance, consequently limiting availability of metals for biological uptake. pH can be analyzed using an electronic pH meter (EPA method 150.2). Small towns without access to a laboratory or to meters can conduct pH measurements using techniques such as a simple litmus paper test. This test can be accomplished by volunteers without scientific training and can be purchased at a minimum price.

Dissolved Organic Carbon

DOC is also known to complex with, or chemically attach to, heavy metals. This concentrates the metals in the dissolved phase, further affecting what is available for biological uptake. DOC is a

factor associated with the overall quality of stormwater and will provide important information on the contribution of stormwater runoff to the overall health of Lake Champlain (National Research Council, 2008). There is no acceptable method outlined by the EPA, although DOC can be analyzed by semi-automated colorimetry like phosphorus and nitrogen (Hach Instrument Manual).

Total Suspended Solids

Total suspended solids (TSS) is another measure associated with the overall quality of stormwater runoff. Pollutants such as phosphorus and metals are attached to suspended particulate solids, so it is necessary for towns to include TSS, a measure of the amount of particulate matter in water, as an analysis parameter. Additionally, high amounts of suspended solids increase turbidity in a water body (Coulter et al., 2004). Turbidity decreases the amount of light available in an aquatic ecosystem, which has detrimental effects on aquatic plants (Bunn, 1999). TSS can also be analyzed by semi-automated colorimetry (Hach Instrument Manual). Understanding these parameters in addition to the pollutants themselves will provide monitoring agencies and town officials with a better understanding of stormwater runoff composition.

Chemical Oxygen Demand and Biochemical Oxygen Demand

Chemical Oxygen Demand (COD) and Biochemical Oxygen Demand (BOD) are other parameters that should be incorporated into any town monitoring scheme to analyze ecosystem health. BOD is a proxy for the amount of organic material in the water. If there are exorbitant amounts of organic material in the water, the BOD will be elevated, possibly leading to oxygen depletion and death of aquatic organisms such as fish and insects. Specifically, BOD is defined as the amount of dissolved oxygen needed by aerobic biological organisms in water to break down organic material present in a given sample. The more organic material there is present in a sample, the higher the BOD.

COD, on the other hand, measures the total quantity of oxygen required to oxidize all organic material into carbon dioxide and water (EPA, 2011). COD will always be larger than BOD because it involves both oxygen depletion due to activity of microorganisms, as well as chemical processes that are not directly related to amounts of organic material or water quality. Previously, wastewater treatment management focused on decreasing BOD and COD to improve water quality, and these two parameters are commonly measured in the NSQD dataset. The EPA approves the colorimetric method as a valid detection of COD. For measuring BOD, the EPA recommends first collecting samples to overflowing in an airtight bottle. If analysis is not performed within two hours of collection, samples should be stored at 4 °C. Regardless, it is recommended that analyses are conducted within 6 hours of collection. The procedure involves diluting the sample with a buffered water solution, measuring dissolved oxygen (DO) with an iodometric measuring electrode, incubating samples for 5 days at 20 °C, and re-measuring DO, where BOD is calculated as the initial DO minus the final DO, divided by the volume used (EPA Method 5210B).

BOD stormwater runoff analysis should be prioritized below nutrient and heavy metal measurements. BOD is usually associated with wastewater byproducts. However, the main source of contaminants leading to BOD in surface runoff comes from feedlots (NRDC). Analyses for BOD should primarily take place around dairy farms and other agricultural sites. BOD and COD will be important parameters if a town is collecting samples from an agricultural stormwater outfall point.

1.3 Monitoring Plan for the Town of Middlebury

Middlebury is a small town of roughly 8,200 residents (Middlebury Vermont: Shire Town of Addison County). The downtown section, where the most development has taken place, is directly adjacent to Otter Creek. The majority of the town's impervious surface drains directly into the Creek, which flows into Lake Champlain (Figure 1.2). For Middlebury to implement a stormwater

monitoring program, a team of planners, scientists, and water quality experts should assemble and determine the scope and scale of the program. The town is just beginning to think about stormwater as it considers how and where development should take place. Thus, Middlebury needs to define specific goals for the monitoring program, which will include determining a baseline for the current quality of stormwater runoff in the town, finding problem areas where pollutant loading is high, and determining the locations where LID and other BMPs would be most effective.

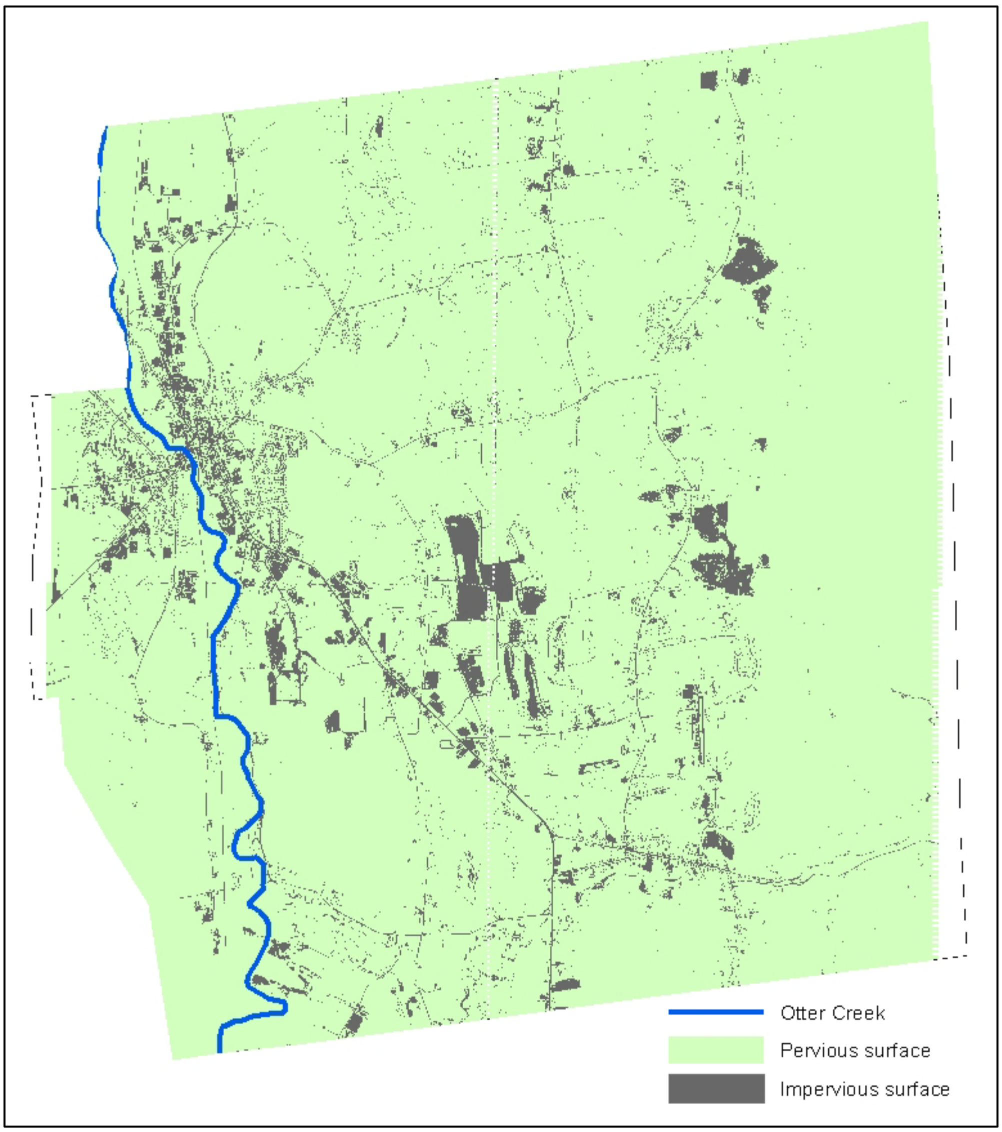

Figure 1.2. The development pattern of Middlebury in relation to Otter Creek.

We designed a monitoring plan to fulfill the second goal of identifying potential problem areas. We selected three sites in Middlebury that the town can incorporate into a monitoring program to determine sources of stormwater contamination (Figure 1.3). These sites are representative of the different land use types in Middlebury (Figure 1.4): one is urban, one is residential, and the last is agricultural. The urban site is 72.5% impervious, the residential site is 21.1% impervious, and the agricultural site is 20.3% impervious. We recommend that the town begin to collect samples from each of these three sites. They are all located where stormwater infrastructure exists and have single, easily accessible drainage outfalls ideal for collecting samples. The town can install automatic samplers at these three sites in order to reduce variability in the data.

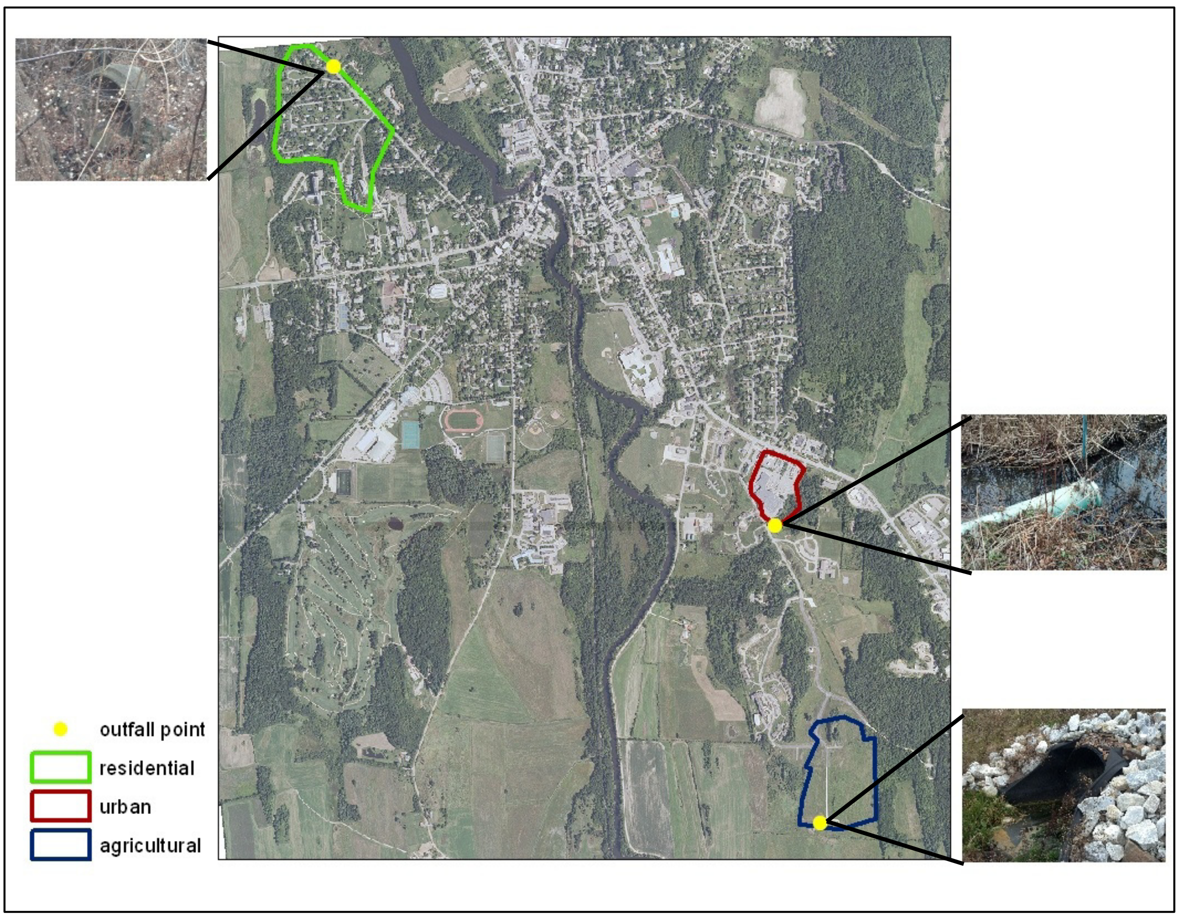

Figure 1.3. The three sites and their sub-drainage basins that we recommend the Town of Middlebury sample. They represent different land use types within the town.

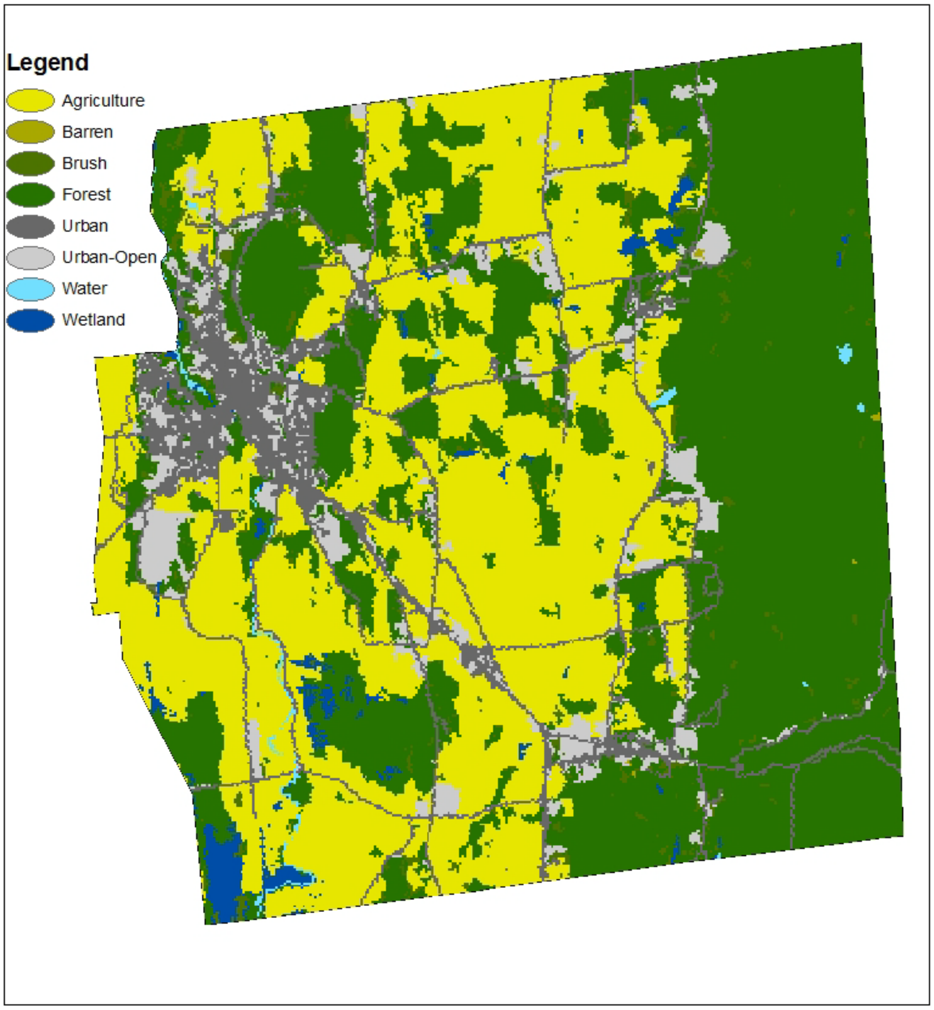

Figure 1.4. Land use types in Middlebury (data from Vermont Center for Geographic Information www.vcgi.org). Middlebury consists of 13.1% urban, 35.9% agriculture, 6.7% brush, 16.2% forest, 17.9% water, 4.1% wetland, 0.3% barren ground, 5.8% open grass/ground.

Using GIS, we determined rough estimates of the drainage basins (Figure 1.3). The drainage basins for each of the outfall points are slightly different in size, so the town will have to control for drainage area. We calculated the areas of the estimated drainage basins to be: 54,120 m^2 for the developed site, 225,703 m^2 for the residential site, and 139,396 m^2 for the agricultural site. For more accurate estimates of the watershed areas, the town should use hand-held GPS units to map the flow of water during a storm, since time constraints and unusually dry weather prevented us from

gathering this data. The town could collaborate on a GIS project with Middlebury College in which students would map the drainage areas of these sites and incorporate them into GIS analysis.

Ideally, the town should invest in automatic samplers rather than rely on grab samples to reduce errors in sampling and analysis. Automatic samplers would cost about $1200 to buy or $75 per day to rent (U.S. Environmental Rental Corporation) and require specific installation. The town should place automatic samplers at the three sites we identified above. The samplers should be programmed to process flow-weighted composite samples, since these have been proven to be the most accurate sample type. If there are more sites the town would like to investigate, town planners can form a team of volunteers to collect grab samples and provide training to reduce some of the errors associated with this sampling method.

For any grab sampling the Town of Middlebury might do, acid-washed or sterile 125 mL HPDE plastic bottles with lids are sufficient sampling containers. At least three samples should be collected at each site during each storm event, with the first being as close to the onset of the storm as possible to collect the "first flush," if there is one. To recruit samplers, the town can use the model of the ACRWC and establish a community-based sampling program. A professional would train volunteers on how to collect grab samples from sampling sites where using automatic samplers is not feasible. In addition to town residents, Middlebury can take advantage of Middlebury College's steady flow of students looking to serve their community as well as to do research. The town can delegate some of the sampling and analysis to town residents and to students in order to reduce some of the financial and time constraints that arise from employing professionals, while giving students opportunities for learning and community involvement.

The sampling scheme is designed to create a comprehensive understanding of stormwater quality, so samplers will collect as many samples as possible within time and resource constraints. At the least,

samples should be taken at varying points in the year in order to avoid the bias of sampling during a single season (National Research Council, 2008). Middlebury receives precipitation in the form of snow in winter, which melts in the spring, creating periods of very little runoff and of increased runoff due to snowmelt. Thus, it is important to collect samples from a variety of rain events throughout the year as well as during the spring snowmelt in order for the results to be representative of the total annual pollutant concentrations. The National Research Council (2008) recommends monitoring around 30 events for each site over a two- or three-year period in order to obtain a statistically significant amount of data. After the initial period, the town can check the sites as it sees fit. If the program identifies sites that have high pollutant concentrations, the town should continue monitoring at those sites until the issues have been addressed.

Given the problems of phosphorus loading in Lake Champlain and the Lake's proximity to Middlebury, phosphorus should be included in the monitoring program. The town should also analyze runoff for nitrogen, heavy metals, TSS, COD and BOD as indicators of stormwater quality. When possible, Middlebury should use EPA-approved methods for analyzing these parameters. However, the town's monitoring program is not part of the EPA's monitoring of MS4s, so simpler methods may be used, provided that they have similar detection limits. For instance, simple colorimeters can be used to analyze for parameters such as phosphorus, nitrates, and nitrites. Different reagents are utilized for this analysis and can be purchased in individual, pre-measured packets for under $100 per 100 tests (Hach Instrument Manual). The simplicity and relatively low cost, aside from initial instrument purchase, make colorimetric analysis an attractive method for analyzing these parameters.

The Town of Middlebury has already established a relationship with Middlebury College, which has access to instruments and other resources necessary for sample analysis. This relationship is

extremely beneficial, considering the cost of professional sampling personnel and lab water sample analyses (Table 1.2). We suggest that Middlebury delegate as much of their analysis as possible to College students and labs to reduce costs.

Table 1.2. Costs for various tests of individual contaminants in stormwater at the Vermont Department of Environmental Conservation Lab.

Test	Cost per Test ($)
Mercury	24
Arsenic, Zinc	32
Cadmium, Chromium, Copper, Iron, Lead, Nickel	120
Ammonia	10
Phosphorus, total or dissolved	16
Nitrate + Nitrite	20
pH	6
BOD	62
Total suspended solids	20

When the analysis is complete, the town should carefully consider the findings. It should determine whether the pollutant concentrations are acceptable, and for those that are not, it should look into BMPs to mitigate the problems. These BMPs will likely include LID practices which are designed to slow down the flow of stormwater, allowing it to percolate through plants and other materials into the soil. This process allows many of the pollutants that stormwater carries to be filtered, thus preventing them from entering the water system. More information on LID can be found in Chapter 2. Although some of these changes would be expensive, especially for a small town like Middlebury, this cost can be offset by a utility. Stormwater utilities charge a fee to residents based on the estimated damage they levy on the water system through stormwater runoff from their property. This fee may be calculated as a universal flat charge or may depend on impervious surface area, depending on the utility. Fees are used for stormwater management, mitigation, and/or treatment.

More information regarding the proposed runoff management utility for Vermont is found in Chapter 3.

1.4 Pilot Monitoring Project in Middlebury

1.4.1 How We Chose Sites

Previous studies sampled stormwater from large watersheds representing whole cities and agricultural areas covering many hectares (Groffman et al., 2004; Coulter et al., 2004; McFarland and Hauck, 1999). In comparison, our sites, described below, are much more localized and small scale. This approach allowed us to gauge surface water flow with higher accuracy and to attribute pollutants to characteristics of the landscape or land use type. This choice required completion of on-the-ground observations of where stormwater flowed rather than relying on GIS analysis alone. However, it allowed us to pinpoint outfalls for specific areas within the town of Middlebury. We used GIS data showing the stormwater drainage system of the town to determine the origins of the runoff at our sites from the stormwater catchment system (Figure 1.5). This methodology allowed us to directly correlate water runoff quality with specific urban structures within the town.

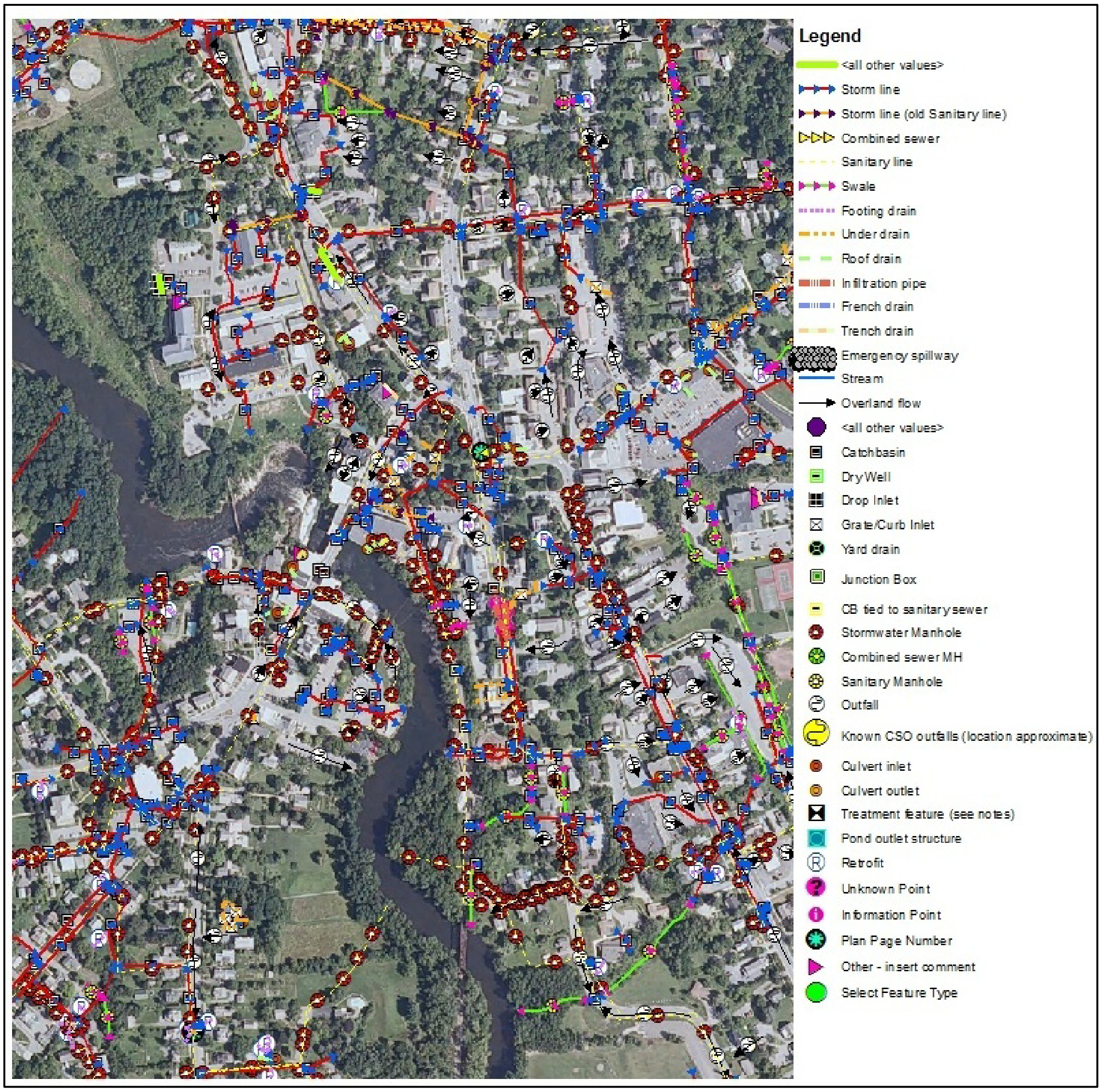

Figure 1.5. Stormwater drainage system of downtown Middlebury (data courtesy of Ethan Swift).

Our sites are representative of two urban areas with comparatively high percentages of impervious cover (Figure 1.6). The first site, Marbleworks, drains a commercial area with a large parking lot, as well as a short grassy slope, and flows directly into Otter Creek. The second site, Bakery Lane, drains a small network of streets, commercial, and residential buildings, as well as a steep vegetated slope adjacent to a major roadway; it also flows directly into Otter Creek.

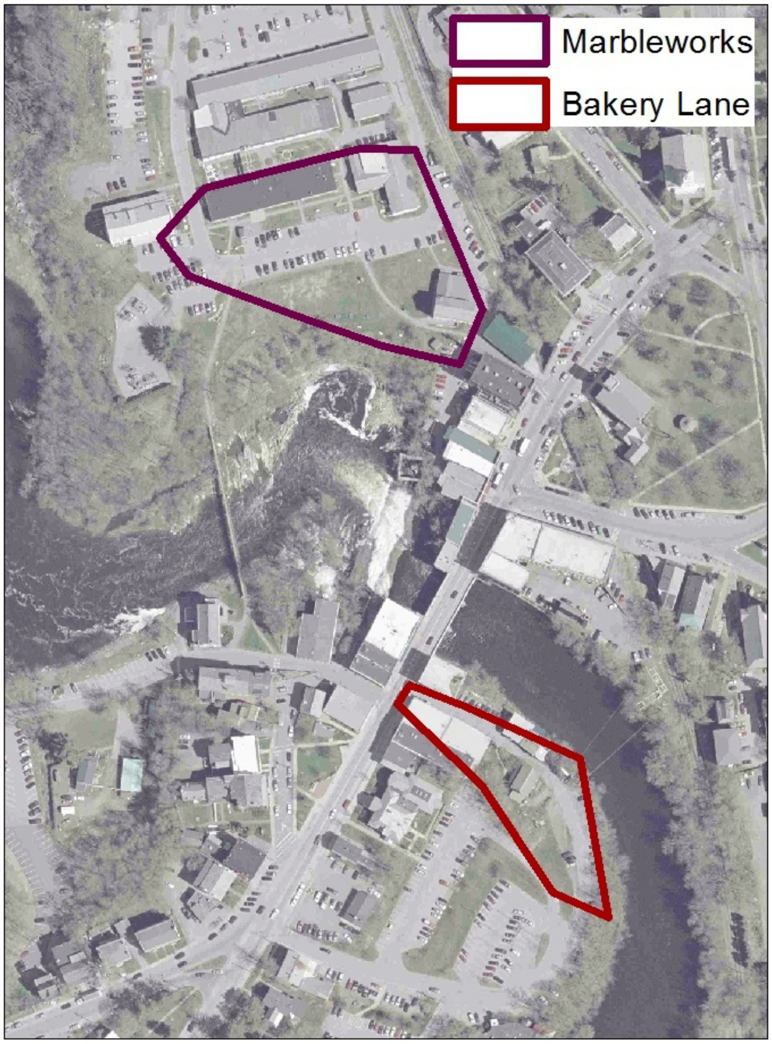

Figure 1.6. Sub-drainage basins of the two sampling sites that we chose in Middlebury, VT. This map is a close-up of downtown Middlebury, centered on the Otter Creek waterfall at the center of town. The Marbleworks site is 50.6% impervious and the Bakery Lane site is 58.5% impervious. The Marbleworks site drains an area of 9,402 m^2, and Bakery Lane drains an area of 3,896 m^2.

One requirement for our sites was accessibility. In the effort to reach our sites during the first flush all sites were geographically restricted to being relatively close to Middlebury College. Furthermore, as we collected grab samples at each site during each rainfall event, a single outfall point accessible by foot and draining the entire designated sub-watershed was necessary in order to correlate the pollutant levels in our samples to percent impervious cover of each drainage area (Figure 1.7). Taking a sample from one point with a known drainage area allowed us to relate concentrations of

pollutants in the sample to the total amount of these contaminants washed from that drainage area. These contaminant levels could then be related to the percentages of impervious cover within the drainage area.

Figure 1.7. Photos of the Marbleworks (left) and Bakery Lane (right) outfall points that we sampled from.

We chose these two sites to represent stormwater runoff from urban Middlebury. While the two sites have differing drainage areas, they are both characterized by a high percentage of impervious cover consisting of a mixture of parking lots, streets, and roofs (Figure 1.6). While previous studies have indicated that different types of impervious area have different pollutant runoff profiles (Pitt et al., 2004; Huang et al., 2007), samples from our chosen sites will provide information about the generalized effect of the town's impervious surface on stormwater runoff. Once we chose our sites, we determined the flow pattern of stormwater using GPS, GIS maps, and field observations, and from this information, we estimated the sub-drainage basins of the two sites. We calculated the area of impervious surface within the sub-watersheds and found that the Marbleworks site is 50.6%

impervious and the Bakery Lane site is 58.5% impervious. The Marbleworks site drains an area of 9,402 m^2, and Bakery Lane drains an area of 3,896 m^2. These analyses enabled determination of stormwater quality as related to the size and characteristics of the sub-watersheds.

1.4.2 Methods

Sample Collection

Automatic samplers were outside the scope of this project, so we collected grab samples from each of the two sites during each rain event during the study period (mid-October through early-December). Once a substantial amount of rain had fallen, we collected samples by holding sterile 125 mL HDPE Nalgene bottles (Thermo Scientific) at the outfalls. Samples were frozen and stored until analysis could be completed.

Sample Analysis

Our analyses of total phosphorus, dissolved phosphorus, nitrates, nitrites, and total suspended solids were run using a Hach DR/850 colorimeter from Hach Company (Loveland, Colorado). Reagents for the ammonium-molybdate reaction were purchased from Hach Company in the form of pre-measured "pillow packets." We followed the manufacturer's recommendations for all analyses. The EPA accepts the use of such a colorimeter for these parameters in measuring contaminant concentrations in wastewater; and we assume it also works for stormwater runoff. Lead and cadmium analyses were conducted using GF-AAS at Middlebury College (see Appendix A.2 for further details).

1.4.3 Results and Discussion

The Bakery Lane site had higher total pollutant concentrations than the Marbleworks site, despite the latter covering a larger area (Table 1.3). Total and dissolved phosphorus, nitrate, nitrite, and TSS

concentrations per unit area of impervious surface (Table 1.4) were also higher for the Bakery Lane outfall point than Marbleworks. One possible explanation is that construction recently occurred at the Bakery Lane site for the Cross Street Bridge. Construction results in soil erosion, which increases TSS concentrations in a site, consistent with the elevated TSS at Bakery Lane (Brezonik, 2002). As indicated in the parameters for analysis section, phosphorus is suspended in water through attachment to particulate matter. Accordingly, we found a high correlation ($R^2 = 0.88$) between total phosphorus and TSS (Figure 1.8).

Table 1.3. Average concentrations of important water quality indicators for stormwater from the two sample sites.

Parameter	**Average Concentration**	
	Marbleworks (n=4)	Bakery Lane (n=2)
Total Phosphorus (mg/L)	0.17	0.48
Dissolved Phosphorus (mg/L)	0.11	0.45
Nitrates (mg/L)	0.00	0.60
Nitrites (mg/L)	0.02	0.02
Total Suspended Solids (mg/L)	40.50	71.00
pH	6	6
Lead (µg/L)	<5	<5
Cadmium (µg/L)	<2.5	<2.5

Table 1.4. Pollutant concentrations for the Marbleworks and Bakery Lane sampling sites per unit area of impervious surface. All concentrations are in mg L^{-1} m^{-2}.

Parameter	Average Concentration per Unit Area Impervious Surface	
	Marbleworks	Bakery Lane
Total Phosphorus	$3.5x10^{-7}$	$2.08x10^{-6}$
Dissolved Phosphorus	$2.36x10^{-7}$	$1.95x10^{-6}$
Nitrate	0	$2.63x10^{-6}$
Nitrite	$4.52x10^{-8}$	$1.03x10^{-7}$
Total Suspended Solids	$8.51x10^{-5}$	$3.12x10^{-4}$

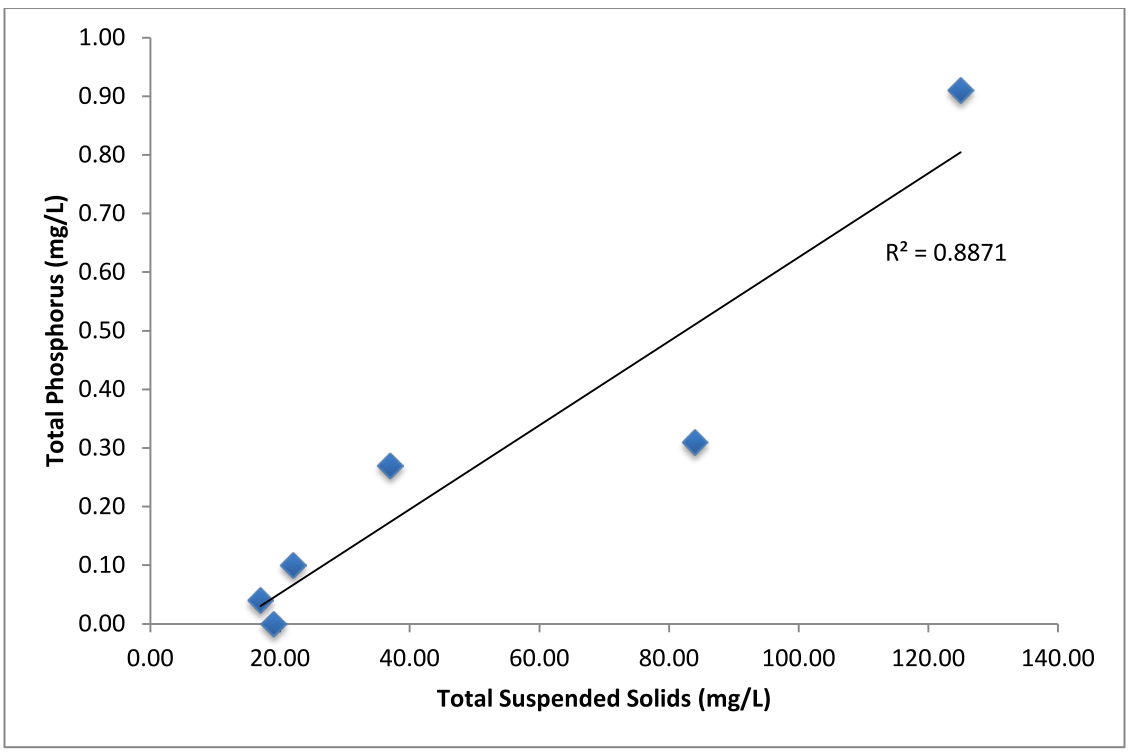

Figure 1.8. This figure shows the relationship between total phosphorus and total suspended solids for each of the samples.

Figure 1.9 displays the relationship between the intensity of a rain event, as determined by the flow rate of the stormwater runoff, and the concentration of pollutants. Correlation coefficients (R^2) between flow rates and total phosphorus, dissolved phosphorus, nitrates, and nitrites were less than

0.5, indicating little or no correlation between the amount of precipitation and the pollutant concentrations entering Otter Creek for our limited sample set. Although the literature suggests that concentrations increase with rain intensity, these results may indicate that in the Town of Middlebury, other factors determine the pollutant load (Maestre et al., 2004). Our results suggest pollutants are equally likely to enter the Creek regardless of the amount of rain. The Town of Middlebury needs to collect more samples to determine whether this trend will hold. Based on these limited results, we recommend the town continue to sample during rain events of all intensities.

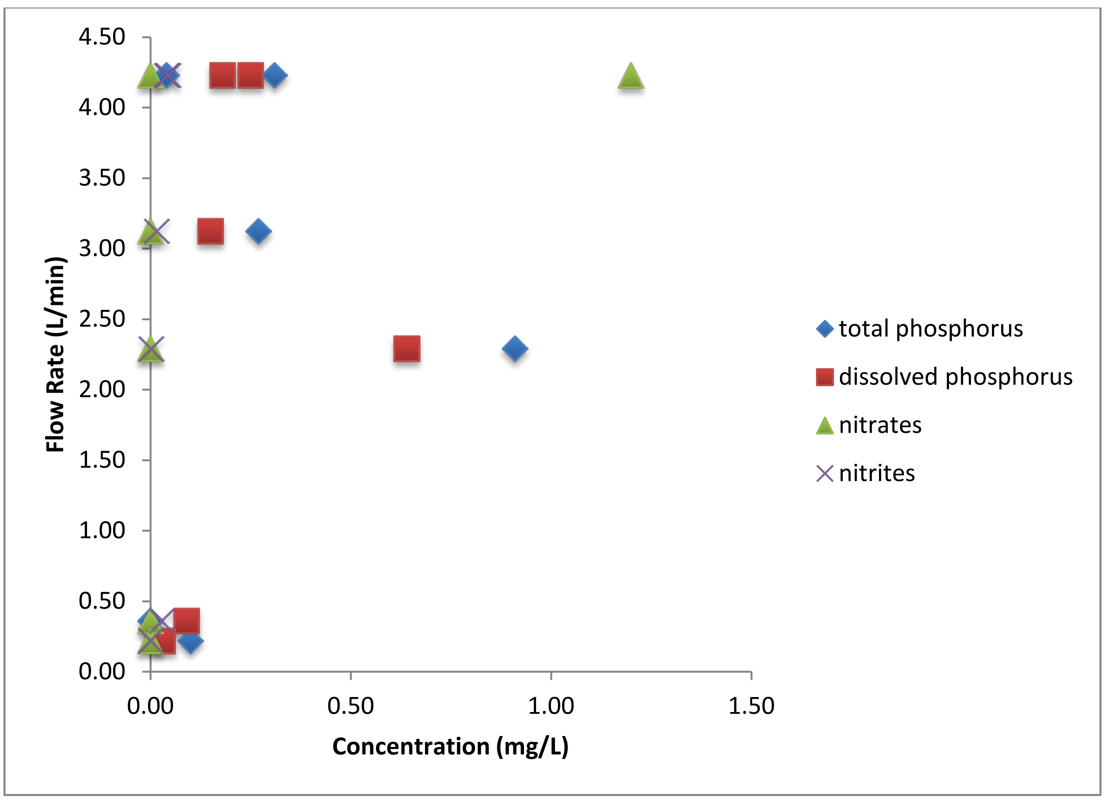

Figure 1.9. This figure shows the relationship between flow rate and pollutant concentrations for total phosphorus, dissolved phosphorus, nitrates, and nitrites.

Lead and cadmium levels were below quantifiable limits. This finding may be explained by the lack of major industrial activity at either of the sites. Despite these optimistic results, further monitoring should continue, and Middlebury should analyze for other metals in order to ensure this was not an anomaly.

Stormwater data are highly variable, and our data are no exception. It is difficult to draw conclusions about trends in stormwater pollution because we were only able to collect a few samples and only collected one sample per storm event. In addition, we collected grab samples, which, as noted above, yield highly variable results. Flow rates from outfall points varied widely, resulting in different pollutant EMCs for each storm event. A large amount of stormwater pollution was likely missed because we were unable to collect samples during the first flush of any of the rain events. This small number of samples was highly variable and prevents us from drawing definitive conclusions about the quality of Middlebury's stormwater. Middlebury should continue to collect samples over a larger time frame and install automatic samplers to obtain flow-weighted composite samples in order to address this variability.

1.5 Recommendations for Future Research

The purpose of our proposed sampling design is to allow volunteers to participate and contribute to stormwater sampling in the Town of Middlebury. The next step is to organize and coordinate a dedicated force of trained volunteers to collect and analyze samples, which will hopefully yield consistent, if not statistically significant results. We recommend that experts and experienced volunteers help educate and train new volunteers. The relatively small nature of the sub-drainage basins allows volunteers to sample locally, from wherever they work or live and to store their collected samples in a cooler until they have a chance to deliver the samples for testing. The more volunteers and samples collected over time, the greater the chances of overcoming variability in the data. Finally, the mapped sub-drainage basins can be used to help town planners and local property owners better understand how water flows in urban areas on a micro-scale to help make more informed decisions when repairing, retrofitting, and implementing LID infrastructure. This

monitoring program reconnects communities to their watershed and encourages members to get involved in sampling, research, and future planning to reduce non-point sources of pollution.

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Note: GIS data were obtained from the Vermont Center for Geographic Information (VCGI – www.vcgi.org), the Middlebury College Geography Department, and Ethan Swift.

Appendix

A.1 Sample Collection

Table 1.5. Samples collected from two sites in Middlebury.

Sampling Location	Date	Time	Level of Flow	Flow Rate (L/min)	Weather Conditions / Other Notes
Marbleworks	10/30/2011	13:07	low flow/trickle		sunny and clear skies, first snowfall previous night, snowmelt
Marbleworks	10/30/2011	13:08	low flow/trickle	0.36	sunny and clear skies, first snowfall previous night, snowmelt
Marbleworks	11/10/2011	17:38	low flow/trickle	0.36	began raining at 5:05PM, drizzle
Marbleworks	11/10/2011	17:39	low flow/trickle	0.22	started raining at 5:05PM, drizzle
Bakery Lane	11/10/2011	17:45	insignificant flow	0.22	
Marbleworks	11/14/2011	20:52	significant flow	3.75	steady rain, started raining at 7:15PM
Marbleworks	11/14/2011	20:53	significant flow	2.50	steady rain
Bakery Lane	11/14/2011	20:59	significant flow	0.83	steady rain
Bakery Lane	11/14/2011	21:00	significant flow	3.75	steady rain
Bakery Lane	11/16/2011	16:08	sufficient flow	2.27	steady rain, started raining 3:30PM
Bakery Lane	11/16/2011	16:09	sufficient flow	2.10	steady rain
Marbleworks	11/16/2011	16:18	significant flow	4.17	started raining 3:30PM
Marbleworks	11/16/2011	16:18	significant flow	4.29	started raining 3:30PM

A.2 Graphite Furnace Atomic Absorption Spectrometry (GF-AAS) Methods

Trace-metal grade $HNO_{3,}$ purchased from Fisher Scientific (Fairlawn, NJ), was used to acidify samples to 1% HNO_3 by volume. A Picotech2 (resistivity 18 mΩ) system (Hydroservices and Supplies, Inc., Durham, NC) was used to purify deionized water used in the acidification.

Certified reference material (CRM) 1643e "Trace Elements in Water" was obtained from the National Institute of Standards and Technology (Gaithersburg, MD) and used for a quality control. We used a matrix modifier solution of 3 µg Mg and 50 µg PO_4^{3-} per 5 µL, made from $Mg(NO_3)_2$ obtained from PerkinElmer Chemical Company (Waltham, MA) and $NH_4H_2PO_4$, (purity >99.99%) from Sigma Aldrich Co. (St. Louis, MO, USA).

Analysis of Middlebury stormwater was conducted using a PerkinElmer graphite furnace atomic absorption spectrometer (GF-AAS) 600 equipped with an AS800 auto sampler, Pb and Cd Lumina electrodless discharge lamps, and WinLab32 for AA control software. A Pb calibration curve was constructed between 5 – 100 ppb lead by automated dilutions of a 100 ppb lead standard to 5, 20, 50, and 100 ppb. A Cd calibration curve was constructed between 2.5 and 50 ppb cadmium by automated dilutions of a 50 ppb Cd standard to 2.5, 1, 25, and 50 ppb. Best fit lines were calculated using WinLab32 for AA control software with $r^2 > 0.99$ for both the Pb and Cd curves.

Triplicate measurements, delivered in 20 µL increments with 5 µL of matrix modifier, were taken of all Middlebury stormwater samples, the method bank, and Trace Metals in Water CRM. For Pb, detection was conducted at 283.3 nm with a slit width of 0.7 nm while Cd detection was conducted at 228.8 nm with a slit width of 0.7 nm. A Zeeman background correction was applied to all atomic absorption signals. There was an internal Argon gas flow at a rate of 250 mL/min that was interrupted during the atomization step. The temperature programs used for lead and cadmium analyses can be observed in Table 1.6 and Table 1.7.

Table 1.6. Temperature program for lead analysis by GF-AAS.

Step	Temp (ºC)	Ramp time (s)	Hold time (s)
Drying	110	1	30
Drying	130	15	30
Pyrolysis	850	10	20
Atomization	1600	0	5
Clean	2450	1	3

Table 1.7. Temperature program for cadmium analysis by GF-AAS.

Step	Temp (ºC)	Ramp time (s)	Hold time (s)
Drying	110	1	30
Drying	130	15	30
Pyrolysis	500	10	20
Atomization	1500	0	5
Clean	2450	1	3

Chapter 2 Putting the LID on Stormwater

Peter Hirsch, Nina Kelly, Max Odland and Sierra Young

2.1 Executive Summary

Problems such as nutrient loading in stormwater continue to affect Lake Champlain. Stormwater in Vermont is currently regulated by Act 250 and the Vermont Water Quality Treatment Standards (WQTS). These programs regulate stormwater effectively in new developments, but do not adequately address stormwater on existing developed sites. Low impact development (LID) presents a viable option for reducing stormwater volume and pollutant levels from new and existing sites. However, several barriers hinder widespread application of LID practices in Vermont: implementation and maintenance costs, lack of public and professional education, concerns over safety and aesthetics, and the complicated nature of the permitting process and town zoning codes. We recommend that the Vermont Department of Environmental Conservation (DEC) undertake four initiatives to overcome these barriers.

(1) The DEC should establish continuing education units focusing on LID for professionals. Educators will visit businesses individually to explain the technical details of implementing LID in Vermont, give professionals a means of communicating the benefits of LID to clients, and guide professionals through the permitting process. This program is mutually beneficial for the DEC and for professionals who require education credits.

(2) The DEC should increase the visibility of new and existing LID projects by instituting an LID Project of the Month award and by networking with universities and other institutions. The DEC should solicit submission of LID project examples from around the state with photos and

descriptions of how each project meets the DEC's green infrastructure goals. The DEC should then feature exceptional LID projects through the Vermont DEC website, social media, and local news venues. Many institutions look to promote themselves through their sustainability initiatives. The DEC should make use of these institutions for outreach, education and volunteer work.

(3) The DEC should partner with state Conservation Districts to sponsor LID retrofit design competitions in each watershed and provide the winning designs with funding to help construct their projects. A statewide runoff management utility, proposed in Chapter 3 of this report, could fund these competitions.

(4) Finally, the DEC should streamline stormwater permitting to make the process more user-friendly. The DEC could minimize paperwork necessary for projects that demonstrate maintained or improved pre-development runoff conditions. The DEC should also create a flowchart illustrating the stormwater management permitting process on the DEC Water Quality Division website. This will make the permitting process more transparent for applicants and ensure that the DEC receives accurate and complete permit applications. Both applicants and the DEC will benefit from a more efficient review process.

2.2 Introduction

Vermont's continued development has led to an increased proportion of impervious surfaces within the state. During storm events, runoff flows much more quickly over impervious surfaces than vegetated areas, which accelerates erosion (Brabec, Schulte and Richards 2002). In addition the stormwater collects pollutants as it flows over impervious surfaces, including nutrients such as phosphorus. In recent years, phosphorus loads from such runoff have damaged Lake Champlain through a process known as cultural eutrophication, which causes potentially toxic algal blooms and

degradation of the lake's aquatic ecosystem (Lake Champlain Basin Program 2008). The general public has historically paid little attention to stormwater management issues (Melosi 1999). However, as Lake Champlain beach closures contribute to a lowered quality of life for Vermonters and lost revenues from tourism, stormwater awareness has grown, particularly following Tropical Storm Irene in August 2011.

This chapter presents an overview of the benefits, challenges and successes of Low Impact Development (LID) practices for stormwater management in Vermont. Traditional stormwater management practices involve directing the flow of runoff into catch basins, which connect to a system of underground stormwater pipes. These eventually discharge into rivers and lakes (Melosi 1999). In contrast, LID involves designing buildings, drainage infrastructure and landscapes to restore and maintain natural hydrologic function, minimize impervious surfaces, and maximize natural absorption and filtration of stormwater (EPA 2007). LID stormwater management systems are often less expensive to build and maintain than their conventional counterparts and therefore represent a cost-effective approach to minimizing water pollution (EPA 2007, UNH Stormwater Center et al. 2011). Despite the obvious benefits of using LID over traditional stormwater management strategies, several barriers impede its widespread application: lack of public and professional education concerning stormwater management and LID practices, lack of consistent funding for LID projects, and a complicated and inconsistent set of regulations regarding LID projects throughout the state. This chapter outlines means for the VT DEC to address these issues and functions as a resource guide for individuals and businesses intending to implement LID projects.

2.2.1 Stormwater Regulations in Vermont

Rapid growth and development in Vermont during the 1960s and 1970s resulted in the loss of natural areas. Vermont residents feared that without land-use regulation, the state would lose sensitive ecosystems to development. In the spring of 1970, the Vermont Legislature passed Act 250, a regionally administered, comprehensive land use law (State of Vermont Environmental Board 2003). Today, Act 250 plays a significant role in how land-use policy interacts with stormwater management in Vermont. In addition to Act 250, the Vermont Stormwater Manual regulates many projects over which Act 250 exercises no jurisdiction. Much of the complication involved in permitting LID projects comes from the challenge of navigating a labor-intensive permitting process.

Act 250 applies to most large commercial and industrial projects, including residential construction of ten or more units, and subdivisions of ten or more lots. Any construction above 2500' elevation and development on one acre or more of land must also obtain Act 250 permits. In towns that have permanent zoning and subdivision regulations, permitting applies to development on ten acres or more (Sanford and Hubert 2000).

Nine district environmental commissions administer Act 250, reviewing applications for development and subdivision permits. Residents within each district serve on the commissions which review Act 250 permit applications. These citizen commissioners typically do not have special training or expertise in environmental or land use planning (Sanford and Hubert 2000). Thus, in order to effectively evaluate plans for development which include LID, members of each district commission should receive specific training about the practices, including site visits to see LID in use.

The first four criteria under Title 10, Chapter 159, Section 6086 of Act 250 relate directly to stormwater. In order to obtain a permit, applicants must prove that their design

1) "will not result in undue water or air pollution,
2) does have sufficient water available for the reasonably foreseeable needs of the subdivision or development,
3) will not cause an unreasonable burden on an existing water supply..., and
4) will not cause unreasonable soil erosion or reduction in the capacity of the land to hold water so that a dangerous or unhealthy condition may result."

LID often involves planting more vegetation and/or preserving natural vegetated areas, both of which yield exemplary conditions in relation to the mandates of Section 6086. However, the review process may take longer than standard stormwater management practices if the members of the district commission do not have experience with LID and do not understand its positive impacts on water quality and reduction of soil erosion. The final Act 250 criterion requires that a project "is in conformance with a duly adopted local or regional or capital program." As authors Robert Sanford and Hubert Stroud point out in their 2000 publication "Evaluating the Effectiveness of Act 250 in Protecting Vermont Streams," this criterion assigns legal power to town and regional plans, documents normally used only for guidance. This highlights the important role that town and regional planners can play in stormwater management. If they write town plans to include strict language that requires LID practices for new development, then the existing Act 250 legislation will lead to more widespread implementation of LID.[1]

In a 1997 publication titled "Vermont's Act 250 Legislation: a Citizen-Based Response to Rapid Growth and Development," Sanford and Stroud write, "Act 250 not only preserves valuable

[1] For further information regarding town plan water quality language and suggestions for improvement, please refer to the "Full Report on the Assessment of Water Quality Language in Town Plans in Addison County," by the Spring 2011 Middlebury College Environmental Studies Senior Seminar: http://www.middlebury.edu/media/view/276853/original/bigbook_townplans_final.pdf.

resources, it also saves or substantially reduces the costs of remediation." LID also reduces the costs of remediation by protecting the watershed from pollutants. However, because Act 250 operates on a case-by-case basis, cumulative impacts of development may occur over time with no watershed-wide land use plan. Developers often preferentially choose small projects outside of Act 250's jurisdiction to avoid the Act 250 review and permitting process. Larger LID projects would result in greater pollutant reduction. In addition, Sanford and Stroud note that as cumulative impacts approach unacceptable levels, developers of projects that require review under Act 250 may face an unfair burden to mitigate damage from previous non-permitted projects (1997). Thus, policy-makers should develop mechanisms that function holistically and individually, encouraging both watershed-scale and on-site stormwater management.

2.2.2 Low Impact Development (LID) Practices

Low Impact Development (LID) practices fall into six categories. The Environmental Protection Agency describes these six categories in its 2007 report, "Reducing Stormwater Costs through Low Impact Development (LID) Strategies and Practices." Projects often employ a combination of practices to achieve integrated stormwater treatment. These categories include:

1) Conservation designs preserve open space, allowing natural processes to treat runoff through evaporation and infiltration.

2) Infiltration practices capture and infiltrate runoff through engineered structures to reduce the volume of runoff, as well as the infrastructure required to manage runoff.

3) Runoff storage practices capture and store water from impervious surfaces for reuse, irrigation or gradual evaporation and infiltration into groundwater.

4) Runoff conveyance practices consist of permeable, vegetated channels, which slow water and convey it away from a site, while accommodating for infiltration. When stormwater conditions overwhelm storage and infiltration structures, these practices mitigate flooding by carrying stormwater through and off of a site. They often have rough surfaces to reduce flow velocity and increase evaporation and settling of solids.

5) Filtration practices treat runoff by physically filtering out solids. They slow water, similar to infiltration practices, but remove more pollutants.

6) Low impact landscaping selects plant species adapted to the micro-climate of a site and requires minimum inputs of labor, water and chemical fertilizers. Healthy and dense plant establishment stabilizes soils and improves infiltration through root growth while also reducing impervious surfaces. Ideally, low impact landscaping also serves to enhance the aesthetics of a site (EPA 2007).

The following lists outline specific examples of each type of LID practice (EPA 2007).

Cluster development

- Open space preservation
- Reduced pavement widths (Figure 2.1)
- Shared driveways
- Reduced setbacks (shorter driveways)
- Site fingerprinting during construction

Figure 2.1. 12th Avenue Green Street in Portland, OR, *Photo: City of Portland, Environmental Services ©2009.*

Infiltration practices

- Infiltration basins and trenches
- Porous pavement (Figure 2.2)
- Disconnected downspouts
- Rain gardens and other vegetated treatment systems

Figure 2.2. Porous pavement at Heritage Aviation in Burlington, *Photo: Kathy Morse.*

Runoff storage practices

- Parking lot, street and sidewalk storage
- Rain barrels (Figure 2.3) and cisterns
- Storage in landscaped depressions containing trees, shrubs or turf
- Green roofs

Figure 2.3. Rain barrel and gutter downspout disconnected from storm drain, *Photo: http://www.ne-design.net.*

Runoff conveyance practices

- Eliminating curbs and gutters
- Creating grassed swales and grass-lined channels (Figure 2.4)
- Roughening surfaces
- Creating long flow paths over landscaped areas
- Installing smaller culverts, pipes and inlets
- Creating terraces and check dams

Figure 2.4. Grassed swale at Middlebury College, *Photo: Kathy Morse.*

Filtration practices

• Bioretention/rain gardens (Figure 2.5)
• Vegetated swales
• Vegetated filter strips/buffers

Figure 2.5. Rain garden outside the Davis Family Library at Middlebury College, *Photo: Kathy Morse.*

Low impact landscaping

• Planting native, drought tolerant plants
• Converting turf areas to shrubs and trees
• Reforestation
• Encouraging longer grass length
• Planting wildflower meadows rather than turf along medians and in open space
• Amending soil to improve infiltration

The Low Impact Development Center's *LID Urban Design Tools* website (http://www.lid-stormwater.net/lid_techniques.htm) and the *Vermont Low Impact Development Guide for Residential and Small Sites* contain detailed descriptions and technical information about specific LID Techniques (Low Impact Development Center 2007, Vermont DEC 2010).

2.3 Barriers to Low Impact Development

Low Impact Development (LID) provides an effective suite of Best Management Practices (BMPs) for reducing the negative impacts (volume, velocity and peak flow) of stormwater runoff. However, a number of barriers exist that have hindered widespread adoption of LID BMPs. These barriers include: perceived costs, maintenance concerns, lack of education, lack of watershed-scale stormwater legislation, and safety and aesthetic concerns.

The cost of implementation and maintenance often impedes projects employing LID. In already developed urban areas, retrofitting proves costly. Where structural management practices such as pipes and catchment basins already exist, city planners may not consider LID's non-structural BMPs necessary. The needs for special construction, manufactured soils to provide adequate infiltration, and increased land area requirements for certain LID practices increase costs. Because most town stormwater management plans do not yet require LID, including it in site designs can extend the review process (NRC 2008).

Questions remain about who would fund inspection and maintenance, especially of BMPs on private property. Owners may hesitate to install LID because they cannot anticipate the total costs over the project's lifetime (NRC 2008). Additional research is necessary to produce accurate cost-benefit analyses for LID including the costs of long-term maintenance schedules for the various Best Management Practices.

However, LID can prove financially beneficial, especially when considered over its lifetime. In some cases, LID practices require less lifetime maintenance than traditional stormwater infrastructure, such as pipes and catch basins, which need regular repair or replacement. LID can prevent revenue loss resulting from decreased tourism and fishing as water bodies, such as Lake Champlain, become unusable (UNH et al. 2011). In this regard, LID can prove more cost effective than traditional stormwater management.

Lack of education for towns and homeowners hinders LID implementation, but resources exist to help overcome educational barriers. The Nonpoint Education for Municipal Officials (NEMO) and Coastal Training Programs (CTP) help officials and community members learn how LID works within a watershed to minimize disturbance to the natural hydrologic regime and about how they can implement LID in their towns (UNH et al. 2011). Illustrations and models can help

communities visually understand LID practices (UNH et al. 2011). Bringing city officials to effective LID sites can help to dispel misunderstandings and provide an informal atmosphere in which to learn and ask questions.

Professional training will teach architects how to incorporate LID into their designs and help engineers understand sizing criteria. Permitting officials should have tools to ensure that calculations for project designs meet each of the Act 250 and VT Stormwater criteria (NRC 2008). Given climate differences among regions within the U.S., regions should develop guidelines for LID that municipalities can quickly and easily adopt, rather than relying on national guidelines (NRC 2008). Stormwater legislation currently operates at the municipal and state scales, which may each set different standards for runoff reduction and treatment within the same watershed. The total maximum daily load (TMDL) for Lake Champlain may place an unfair burden on downstream municipalities to minimize phosphorus runoff if upstream communities have lax standards. In order to effectively address the issue of stormwater runoff and set standard requirements for LID implementation, natural boundaries should be prioritized over political boundaries by drafting watershed-scale legislation (NRC 2008). Authors Allison Roy and Seth Wegner et al. identify six examples of regional-scale stormwater management programs in Australia and the US. In each case, "concern for downstream water quality" drove implementation of LID practices (2008). Where downstream ecosystem impairment has been identified and targeted for improvement, Natural Resource Conservation Districts may gain leverage for implementing regional or watershed-scale management (Roy and Wenger et al. 2008). City officials could readily implement LID into their stormwater plans because Lake Champlain already exhibits clear ecosystem impairment. Watershed-scale implementation of LID would benefit Lake Champlain by reducing cultural eutrophication, thus preserving its ecological and economic value.

Detractors frequently raise safety and aesthetic concerns about LID projects. Where LID practices increase standing water, safety concerns arise over vector-borne diseases such as West Nile Virus (NRC 2008). Towns must carefully consider the costs and risks of pest control measures. Where LID has not been widely implemented, aesthetic concerns about their "weedy" or "messy" look may make people hesitant to adopt it on their own property. Especially in urban areas, residents and planners may need to re-imagine an appropriate urban aesthetic—one that incorporates many natural elements and fewer impervious surfaces.

2.4 Education

To increase the use of LID throughout Vermont, the state must provide more access to education about stormwater runoff and LID. Vermont residents do not have enough knowledge about either of these topics. For example, there is a general misconception that most phosphorus that enters Lake Champlain comes from agricultural runoff. However, roughly half comes from urban sources (Lake Champlain Basin Program 2008). LID practices are relatively new and may sound overly complicated to those who are not familiar with them because incorporating LID requires special permitting in new construction. A successful stormwater education program will inform Vermonters that LID can help lower heating and cooling costs with solutions like green roofs that provide increased insulation. Water collection practices, such as rain barrels can help decrease water costs. LID also improves outdoor drainage and can increase the aesthetic value of a yard that has flooding problems, in addition to simply adding more green vegetation to an outdoor space. Many parties do not know about the economic, aesthetic and environmental advantages of LID and therefore do not stray from traditional construction.

An LID education program should focus primarily on professionals and municipal officials. These two groups will act as leaders in the incorporation of LID throughout the state. Municipal officials

will act from a top-down perspective, including LID in municipal buildings to provide successful examples of LID to the public. The state of Vermont should utilize the NEMO program to better inform officials about LID practices. NEMO acts as a cost-effective solution that teaches officials how to protect their state's natural resources from a local perspective. Design professionals will instigate change from the bottom up. They are responsible for designing new homes and buildings and have the ability to educate their employers about the importance of LID and how it can work in individual projects. Municipal officials and design professionals are responsible for deciding what our built environment looks like and thus are the most important first audience for an LID education program.

After the EPA Phase II Stormwater Rules came into effect, municipalities made a strong effort to increase the public knowledge base about stormwater practices. In addition, developing education programs became not only a regulatory requirement, but also a necessary strategy to increase public participation in meeting the EPA requirements, ultimately improving water quality and reducing pollution (Neiswender and Shepard 2003). The general public will be open to LID practices once successful examples appear in their communities and the education strategies will be more effective with a receptive audience.

The state of Vermont needs to begin with programs that cater to design professionals and municipal officials. Once a solid knowledge base exists in these two sectors, a general public education campaign about LID will follow. The goals of all education programs will be to promote water quality and to publicize other benefits of LID practices. LID practices are a cost-effective way of managing stormwater and more education to all involved parties will increase the use of LID throughout the state.

2.5 Looking to the Future: Proposed Initiatives for the Vermont DEC

The next section of this report proposes four specific initiatives to address gaps in education and awareness and to streamline the stormwater permitting process to overcome barriers to LID implementation. The first initiative is an LID education program to be offered four times per year for architects, engineers and landscape architects, providing them the opportunity to earn professional continuing education credits. The second outlines a way for the Vermont DEC to improve LID outreach by publicizing a successful LID project each month, offering awards for new and existing stormwater mitigation practices. The third is an LID retrofit competition sponsored by the Vermont DEC in partnership with Natural Resource Conservation Districts (NRCDs) with funds from a statewide runoff management utility. The permitting process requires improvement so that it no longer discourages LID in project designs. Thus, the fourth initiative emphasizes a stronger focus on pre- and post-runoff analyses and includes a proposal to create a flowchart of the permitting process. A statewide runoff management utility, as described in Chapter 3 of this report, could generate funds for these four initiatives.[2]

2.5.1 LID Professional Education Program

From interviews with Vermont architects, engineers and landscape architects, it is clear that professionals require education focused on Low Impact Development. The concepts of LID are foreign to them, or they lack the ability to communicate the benefits of LID practices to clients. It is necessary to supply these professionals with the education tools to solve these problems. They

[2] Although beyond the scope of this project, an education program should also target town planners or volunteer town board members so that LID gets into town plans. This should be the role of regional planning commissions, and this work is already underway at the Addison County Regional Planning Commission. The DEC is already focusing on public education, with resources available on the stormwater section of the Water Quality Division website: http://www.vtwaterquality.org/cfm/ref/ref_stormwater.cfm. A statewide utility could also fund public stormwater education programs. In order to not reproduce work done by the DEC, this proposal focuses on professionals working in the private sector for businesses and homeowners.

design our surroundings and thus are the agents to change runoff practices in Vermont. An LID-focused seminar targeting Vermont professionals would provide a mutually beneficial opportunity to promote LID. The Vermont DEC Environmental Assistantship Program (EAP) is the best existing state structure to facilitate such a professional development program addressing these issues. Workshops about LID do exist, such as the Philadelphia Low Impact Development Symposium and StormCon (NCSU 2011 and StormCon 2012), but occur at national conferences requiring professionals to invest their travel time and money to attend. Furthermore, these conferences lack a regional focus. Therefore, a locally targeted program would provide an accessible means of education.

The EAP can implement a program which reaches out to professionals and offers educational services. The program will be small, starting with two educators who travel throughout the state holding seminars. The seminars could occur either through visits to individual firms or through quarterly workshops affording professionals, who do not have the chance to attend individual seminars, the opportunity to receive professional credits. These educators will be certified to offer courses that will provide professionals the Continuing Education Units (CEU) they require every two years to maintain their license to practice. The seminars will be tailored to run during professionals' lunch breaks, minimizing the time commitment. The EAP representatives would function like representatives from manufacturers who currently visit firms and offer a complimentary lunch while demonstrating their product to professionals.

The cost of the program will be kept low because it will have a low overhead. The two educators will need to receive recognition from the American Institute of Architects (AIA) and the American Society of Landscape Architects (ASLA) to guarantee that the courses will provide the professional credits. Additional costs include transportation throughout the state for the two educators and

supplies for workshops and seminars, such as educational materials and food. Like the major national conferences, professionals will be required to invest a minimal fee to attend the quarterly workshops. In the end, the cost of implementing these workshops will be quite low and will not require a significant capital investment from the state.

There will be three main goals of these workshops:

1) Educate professionals about LID practices and their benefits (environmental, economic, and structural)
2) Train professionals to communicate benefits of LID to clients
3) Guide professionals through the permitting processes for LID to ensure they will not be deterred by the extra steps

Although opportunities to take courses on LID do exist, it is imperative that some are held in-state because the others are inaccessible to most working professionals. This also allows content to be tailored to local conditions. With these sessions held locally, it is more likely that professionals will pursue these courses to learn more about LID practices and how to bring them to Vermont.

2.5.2 LID Project of the Month and Outreach

Next, the Vermont DEC should establish a better program for documenting and highlighting LID projects in Vermont. This program will have several components. First, the DEC should present LID Project of the Month awards for new and existing low impact stormwater mitigation sites. Promoting effective and aesthetic LID projects on the DEC website and through social media will both increase the visibility of LID and provide publicity for participants interested in advertising these initiatives.

Interested parties will submit information about their LID projects to the DEC, including photos and short descriptions of each project. Entrants should also justify how their project addresses one or more of the following goals for small-scale LID, as identified by the Vermont DEC Water

Quality Division: "reduce the impervious area at a site, implement infiltration to the maximum extent possible, generate less runoff, utilize building site characteristics to manage runoff, reduce infrastructure operation and maintenance costs, conserve open and green space and ultimately, protect water quality" (Vermont DEC 2011).

For example, a condominium complex in Pelham New Hampshire, were it eligible for the competition, might submit (UNH et al. 2011):

> *Location*: Boulder Hills, Pelham, NH
>
> *Type of development*: Condominium complex
>
> *LID Methods Used*: Porous pavement, curb removal
>
> *Motivations*: saved an estimated $49,000, 6% of total stormwater management costs, by implementing porous pavement rather than traditional catchment basins.
>
> *Challenges*: The roads and driveways of this development were 50% more expensive than traditional asphalt, but the developers saved money on site preparation, erosion control, curbs, and especially on drainage infrastructure.
>
> *Sources of outside Funding*: Not Applicable.
>
> This project reduces impervious surface, generates less runoff, minimizes construction and maintenance costs, and conserves open space by replacing traditional asphalt with porous asphalt, removing curbs, and eliminating the need for large stormwater catchments.

Many successful, aesthetic examples of commercial and residential LID projects already exist in Vermont and in surrounding states, but most of these projects are not well documented. The National Low Impact Development Atlas shows examples of LID projects, but does not have comprehensive coverage of existing projects in Vermont (National NEMO Network 2007). The LID of the Month program will improve statewide documentation of successful LID projects. As new submissions come in, the DEC will catalog the information and make it accessible online by entering it into the National LID Atlas. The submission and recognition process will spur the growth of this resource database. Appendices 2 and 3 of this chapter provide lists of professionals

involved with various aspects of LID as well as several successful examples of LID projects. The DEC should consider these professionals, institutions and projects as candidates to receive the LID Project of the Month award. They may also have the resources and connections to help get this program off the ground.

Next, the DEC should increase its networking efforts with colleges, universities and other institutions in the state. Many institutions are very interested in promoting themselves through their sustainability efforts. Moreover, colleges and universities have a large motivated group of students that would be willing to assist the DEC with its education efforts and with volunteer work.

2.5.3 LID Retrofit Competitions

The Vermont DEC should partner with Natural Resource Conservation Districts to offer an annual LID retrofit design competition for each major watershed in Vermont. Retrofit competitions specifically emphasize improving stormwater management on existing buildings and infrastructure, which is not strictly regulated at the state level in Vermont. Current stormwater permitting regulations apply mostly to new construction projects (VTANR 2002). New construction projects that add more than one acre of impervious surface to a site must meet Vermont's Water Quality Treatment Standards, including capturing 90% of annual storm events and removing 40% of the total phosphorus load in runoff. In contrast, existing sites are only required to reduce impervious surfaces by 20% or treat 20% of their stormwater during redevelopment (VTANR 2002). As many of the urban areas that contribute stormwater to Lake Champlain are already developed, retrofits offer a promising opportunity for improving water quality.

Participants will submit a design proposal that addresses stormwater management for an urban area or an individual site, and will be rated on their project's overall water quality improvement. Winners in each district should receive funding from the DEC to assist with the construction of their project.

Ideally, funding for the contest will come from a statewide runoff management utility proposed in Chapter 3 of this report. Alternative funding can be acquired from federal and state water quality grants to support the winning proposals until such a utility is implemented.

This contest can build on and expand the model of the annual Chittenden County rain garden contest (WNRCD 2011). The rain garden contest scores participants in multiple categories, selecting a winner in each. It also invites all participants to free rain garden workshops and provides free technical advice from a local expert. Organizing contests and providing technical assistance to the whole state might be difficult for one entity or organization to do. Therefore an entity in each major watershed in the state should organize competitions. Free workshops for participants could happen in conjunction with the LID education program outlined above in Section 2.5.1 of this report.

Retrofit competitions will act as a venue for increasing awareness and ownership over stormwater issues. There is a lack of well-documented LID examples in Vermont. The National LID Atlas shows a cluster of examples in the greater Burlington area and in St. Albans, but only a few scattered examples around the rest of the state (National NEMO Network 2011). In fact, most of the examples of LID practices in Vermont are rain gardens in the greater Burlington area, the location of the Chittenden County rain garden contest. Having these contests will provide more high quality examples of LID practices for Vermonters to follow. Winners should be added to the National LID Atlas.

2.5.4 Streamlining Permitting Process: Emphasizing Stormwater Analyses and Flowchart

Stormwater permits are necessary for any development effort which includes an impervious surface area of greater than one acre (Act 250). Currently, the permitting system is arduous, complicated and

time consuming. Professionals and clients alike seek to minimize costs in any project while maintaining a set schedule for completion. Stormwater permits have proven to hinder the development process while driving up costs to cover the necessary hours devoted to permit applications. In order to promote the use of LID, the permitting process must be made more transparent. Two strategies will facilitate and expedite permitting: stronger emphasis on pre- and post-runoff analyses and developing a flowchart.

Between Act 250 and the Vermont Stormwater Management Manual, professionals have a hefty amount of paperwork associated with any development project. The amount of time devoted to permitting translates into financial costs for a project. In one interview, a local civil engineer highlighted that the stormwater permitting process can cost approximately $3,500. The issues with this are clear: it discourages the use of LID over the simplest stormwater management strategy—a single retention pond—through time and cost. The DEC should analyze the permitting process to determine where it can be streamlined.

A stronger emphasis on pre- and post-development stormwater analyses could also improve the permitting process. Civil engineers must conduct an analysis for any project requiring stormwater consideration. These analyses measure the stormwater patterns on the site before construction and model the change in flow characteristics for post-construction conditions. The studies are integral to stormwater permitting because they are highly indicative of the impacts the development will have on the landscape. Therefore, paying more attention to and emphasizing the projection of the studies could minimize additional paperwork by generating accurate calculations for permit applications. As civil engineers conduct more analyses of LID practices, they will improve their baseline understanding of the effect each practice has on the hydrology under local climatic conditions and thus choose the most effective BMPs. This proposal would allow developments whose projected

stormwater conditions are equal to or better than pre-construction conditions to forgo certain areas of the permitting process. The analyses must provide clear evidence that the project's stormwater methodologies will create an unchanged or improved condition focusing on aquifer health, on-site runoff retention or infiltration, erosion, and peak runoff discharge rates. The goal is to provide sufficient information to evaluate the ecological effects of a project while driving down the cost and time allotted to permitting. This greater emphasis on runoff analyses would incentivize utilizing LID over conventional structural stormwater management techniques.

Discussions with design and construction professionals across Vermont revealed a common confusion regarding—and subtle intimidation by—stormwater permitting. While many professionals are very familiar with the issues stormwater presents, and thus the necessity for permitting, they struggle with comprehending the remarkably complex system. The majority of professionals responded favorably to the idea to create some form of flowchart or checklist that illustrates the path of least resistance through the permitting process. This organizational tool would enable professionals to visually and conceptually understand how their project fits into the process. Furthermore, a majority of professionals thought that a flowchart would demonstrate the DEC's promotion of future development, as opposed to some current views that perceive permitting as unnecessarily cumbersome.

While this proposal begins to scratch the surface of permitting language and policy, it is clear that the permitting process is currently not user friendly. Additionally, overlap between the Construction Permit General and Act 250 should be examined to reduce redundancy (Phelps). Hopefully, in conjunction with this proposal, the permitting process can achieve a more favorable perception.

2.6 Conclusion

The health of Lake Champlain depends on effective runoff management at the watershed scale to minimize pollutants such as phosphorus from entering rivers. LID presents a flexible, scalable, cost-effective solution. Vermont needs to increase LID statewide to protect water quality by providing incentives that make LID the easy, financially feasible and beneficial choice. To achieve this goal in the private sector, the Vermont DEC should enact the initiatives outlined in Section 2.5 of this report. Funding would ideally come from a statewide runoff management utility, outlined in Chapter 3, but other funding sources do exist. By raising public awareness of the issues of stormwater runoff and providing the tools necessary to address them, the DEC will empower Vermonters to play an active role in protecting valuable water resources in the state.

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Appendix: Resources for Implementing LID Projects

A.1 Recommendations to the VT DEC

Four Proposed Initiatives:

1. LID Professional Education Program
2. LID Project of the Month and Outreach
3. Retrofit Competitions
4. Permit Streamlining and Flowchart

Identified Barriers:

- Education
- Outreach, Visibility, Documentation
- Funding
- Attention to Preexisting Infrastructure
- Permitting

1. LID Professional Education Program

- VT DEC Environmental Assistantship Program (EAP) to run program

Goals

- Educate design professionals about LID practices and their benefits (environmental, economic, structural)
- Train professionals to communicate the benefits of LID to clients
- Ensure that professionals are not deterred by the permitting process for LID

Program

- Individual Firm Visits
  - Function similar to commercial representative visits to firms
  - Short lunch break lectures provide complimentary meals and LID education
  - EAP representatives receive recognition from AIA and ASLA to provide needed Continued Education Units (CEU) to professionals through LID lectures
- Quarterly Workshops
  - A locally targeted program is more accessible and relevant than national precedents
  - Minimal attendance fee for professionals
  - EAP representatives receive recognition from AIA and ASLA to award needed Continued Education Units (CEU) to professionals through workshops

2. LID Project of the Month and Outreach

- VT DEC presents LID Project of the Month awards for new and existing LID sites

Goals

- Increase visibility of LID through VT DEC website, social media and the National LID Atlas
- Generate publicity for participants

Program

- Participants submit photos and project descriptions to the DEC and justify how the project meets VT DEC Water Quality Division's goals for small-scale LID:
  - Reduce the impervious area at a site
  - Implement infiltration to the maximum extent possible

        - Generate less runoff, utilize building site characteristics to manage runoff
        - Reduce infrastructure operation and maintenance costs
        - Conserve open & green space
        - Protect water quality
    - Candidates include those projects already documented in the National LID Atlas
    - Connect with colleges and universities to assist with LID education and outreach

3. LID Retrofit Competitions

- VT DEC partners with NRCDs to offer annual LID retrofit design competitions in each major watershed in the state

Goals

- Provide funding for well-designed LID projects
- Emphasize stormwater management on preexisting infrastructure without strict regulation
- Provide high quality examples of LID practices for Vermonters to follow through documentation in the National LID Atlas
- Increased awareness and ownership over stormwater issues

Program

- Participants submit design proposals for LID retrofits
- Offer free LID workshops for participants and technical advice from local experts
- Provide funding through a statewide runoff management utility for construction of winning designs
- Obtain additional funding from federal and state water quality grants

4. Permit Streamlining and Flowchart

- VT DEC reorganizes and clearly presents the stormwater permit application process on its website

Goals

- Incentivize LID use over traditional practices through the permit process
- Clarify the permitting process for developers
- Ensure that the VT DEC receives accurate stormwater permit applications

Program

- Streamline Permitting
    - Simplify the process by incentivizing demonstration of BMP's through stronger emphasis on pre- and post-development stormwater analyses
    - Projects that preserve or improve pre-development hydrologic conditions may forgo some permitting steps
    - Emphasize aquifer health, on-site runoff retention or infiltration, erosion and peak runoff discharge rates
    - Identify areas of overlap between Construction Permit General and Act 250
- Create a permitting flowchart
    - Outline the permitting process
    - Provide a visually and conceptually simple resource to professionals
    - This functions as an act of good faith between the DEC and developers while demonstrating a commitment to improving future development

A.2 Successful LID Projects in and near Vermont

Vermont

Heritage Aviation

Location: South Burlington, VT
Type of development: Private company
LID Methods Used: Green roof, rain garden, porous pavement parking lot
Motivations: Information not available
Challenges: Information not available
Sources of outside funding: Not applicable

Heritage Aviation is a private charter air service. In 2009 they constructed the largest green roof in Vermont* on top of their hangar at the Burlington International Airport. They further reduce their impervious cover through a pervious pavement parking lot. In addition, a rain garden gathers water from part of their property for filtration, rather than letting it run off across pavement and runways. Heritage Aviation privately funded these LID Projects without outside support. While this approach was useful for a successful business, it may not be effective for smaller companies, towns and residents without access to the same level of resources.

**see Burlington International Airport, below*

Burlington International Airport parking garage

Location: South Burlington, VT
Type of development: Airport
LID Methods Used: Green roof
Motivations: Information not available
Challenges: Information not available
Sources of outside funding: Information not available

The Burlington International Airport is in the processes of constructing the new largest green roof in Vermont.

Atwater Dining Hall and Allen Hall at Middlebury College

Location: Middlebury, VT
Type of development: Private educational institution dining hall and residential building
LID Methods Used: Green roof, vegetated swales, rain garden, conservation of a natural wetland
Motivations: Information not available
Challenges: Information not available
Sources of outside funding: Not applicable

This project uses a variety of LID strategies to mitigate stormwater from a dining hall and a residential building at Middlebury College. A large green roof covers Atwater dining hall, reducing impervious surface area. Rainwater from the roof is piped to a rain garden behind the dining hall. Water falling on the surrounding area is directed via a swale to the same rain garden. If the rain garden reaches capacity, excess water is piped a short distance to a natural wooded wetland for further absorption and filtration.

Atwater Courtyard at Middlebury College

Location: Middlebury, VT
Type of development: Private educational institution residential buildings

LID Methods Used: Rain garden, vegetated swales.
Motivations: Information not available
Challenges: Information not available
Sources of outside funding: Not applicable

Two large residential buildings were constructed on the Middlebury campus in 2004. Runoff from the dormitories was channeled via a vegetated swale to a rain garden situated down slope of the courtyard between the two buildings. Although the project was effective in catching stormwater, the courtyard has experienced moderate erosion over the years. The College re-graded the area to control erosion, inserting a new storm drain from the previously eroded area to the rain garden, and planted some new trees. Like the other projects the college has undertaken, this one relied on private funding.

Davis Family Library at Middlebury College

Location: Middlebury, VT
Type of development: Private educational institution library
LID Methods Used: Rain garden
Motivations: Information not available
Challenges: See below
Sources of outside funding: Not applicable

The Davis Family Library, located low on a hill on the eastern edge of campus, includes a large rain garden as part of its landscaping. This rain garden catches stormwater from uphill and filters it before sending it to storm drains. This project presented several challenges, including poor initial selection of plant species. The plants originally chosen for the rain garden performed poorly because they were not suited to Vermont's climate. After reassessment, proper plants were chosen. The second main challenge for this project was maintenance. Centrally located and highly visible, it is important to maintain aesthetics in this garden. The site required significant maintenance and removal of weed species for the first few years while desired plants became established. It now requires little maintenance.

Axinn Center at Middlebury College

Location: Middlebury, VT
Type of development: Private educational institution academic building
LID Methods Used: Rain gardens
Motivations: Information not available
Challenges: Information not available
Sources of outside funding: Not applicable

A series of two small rain gardens behind the Axinn Center catch stormwater from the surrounding lawn for filtration and absorption.

Center For Arts Parking Lot at Middlebury College

Location: Middlebury, VT
Type of development: Private educational institution parking lot
LID Methods Used: No curbs and grass-lined ditches
Motivations: Information not available
Challenges: Information not available
Sources of outside funding: Not applicable

The Center for the Arts parking lot may not seem to be helping control stormwater at first look. However, it makes use of vegetated ditches between rows of parking as well as around the outside

of the parking lot. A lack of curbs next to these ditches allows water to flow off the parking lot and be partially filtered and absorbed by vegetation rather than flowing directly to a storm drain.

New Hampshire

Boulder Hills (UNH et al. 2011)

Location: Boulder Hills, Pelham, NH
Type of development: Condominium complex
LID Methods Used: Porous pavement, curb removal
Motivations: saved an estimated $49,000, 6% of total stormwater management costs, by implementing porous pavement rather than traditional catchment basins.
Challenges: The roads and driveways of this development were 50% more expensive than traditional asphalt, but the developers saved money on site preparation, erosion control, curbs and especially on drainage infrastructure.
Sources of outside funding: Not applicable.

This project reduces impervious surface, generates less runoff, minimizes construction and maintenance costs and conserves open space by replacing traditional asphalt with porous asphalt, removing curbs and eliminating the need for large stormwater catchments.

Greenland Meadows (UNH et al. 2011)

Location: Greenland, NH
Type of development: Large retail development
LID Methods Used: Porous pavement, gravel wetland
Motivations: Protecting water quality in adjacent brook. Greenland Meadows also saved a total of $930,000, or 26% of their stormwater management costs, by implementing porous pavement and a gravel wetland.
Challenges: No previous examples to draw on. Paving costs were approximately 50% higher than conventional asphalt, but the developer saw savings in both earthwork and stormwater management, mostly through reduced need for piping and storage infrastructure.
Sources of outside funding: Not applicable

University of New Hampshire Parking Lot Retrofit (UNH et al. 2011)

Location: Durham, NH
Type of development: Parking lot retrofit
LID Methods Used: Bioretention (Rain garden)
Motivations: Information not available
Challenges: Retrofitting existing infrastructure is often expensive compared to new construction. Municipalities with a public works dept. can provide labor and equipment where applicable, leaving materials and design as the main costs. This project ended up costing $14,000.
Sources of outside funding: Not applicable

A.3 Engineers, Architects, Planners, Consultants, etc.

Jenna Calvi -- Waterbury, VT

Green Infrastructure Coordinator

Jenna served as the community partner and professional guide throughout the course of this project. She is an expert in all areas of LID, both in practice and permitting. She provided an invaluable perspective on the issue, editing research to narrow its focus and achieve specific goals. In what could be a discouraging position, she has proven to be an optimist about the future of LID in Vermont.

Luther Tenny -- Middlebury, VT

Middlebury College Assistant Director of Facility Services

Luther employed LID in the drainage plan for Middlebury College. Under his direction the college now filters around sixty percent of the runoff on campus through natural systems. This is achieved through a system of rain gardens, swales and retention ponds strategically placed on campus.

Kevin Behm -- Middlebury, VT

Addison County Regional Planning Commission

The Addison County Regional Planning Commission evaluates and recommends construction and development strategies to municipal authorities. Kevin, in conjunction with coworkers, is an advocate of intelligent development focused on ecological health.

Becca Lindenmeyr -- West Addison, VT

Linden LAND Group

Becca Lindenmeyr is a professional landscape architect with a background in environmental studies. She worked for the EPA and Vermont's Clean and Clear program until she began her career as a designer. She approaches all projects from an ecologically conscious point of view. She recently completed her work on the green roof at Burlington International Airport and on the backyard of a private residence on Lake Champlain employing LID.

Tim Parsons -- Middlebury, VT

Middlebury College Landscape Horticulturist

Tim Parsons holds the unique position as Middlebury College's landscape horticulturist. Recently he oversaw a major landscape effort on campus. The Atwater Turf Battle project re-graded and planted the northeastern campus. The site utilized LID measured to better manage runoff with the addition of a rain garden and native plant species.

Brandon Streicher -- Middlebury, VT

Phelps Engineering

Phelps Engineering, established in 1976, specializes in civil engineering and designing environmental systems for clients. They have kept up to date with the changes the Agency of Natural Resources has made to Vermont stormwater policy. They now possess expertise in designing stormwater management systems. Phelps is a strong presence in the Middlebury community, working with clients such the college to employ LID.

Heritage Aviation -- Burlington, VT
Private Aviation Charter and Maintenance

Heritage Aviation is a green business leader in Vermont. Their facility at Burlington International Airport is LEED gold certified. The facility has LID measures to manage runoff. The green roof and porous pavement parking lot retain and filter runoff.

Fred Dunnington -- Middlebury, VT
Middlebury Town Planner

Fred Dunnington is Middlebury's Town Planner. He oversees decisions concerning infrastructure and the town's water management practice. Fred works with urban systems to shape methodologies for runoff management.

Carolyn Radisch -- White River Junction, VT
ORW Landscape Architects and Planners

Carolyn is a practicing landscape architect who recently completed a commission at Champlain College in Burlington, VT. There she installed a sizeable rain garden as well as porous pavement. She believes that landmark examples of LID are the keys to promoting the future development of LID in Vermont by bringing the issue into the public eye.

Louis Hodgetts -- Randolf, VT
DuBois & King, Inc. Consulting Engineers

Louis is very familiar with LID practices and concepts. He has a critical and pragmatic eye in his work, evaluating the best solution within the client's constraints. He has spent a significant amount of time with stormwater permitting and believes that the process could be made clearer even with his years of familiarity. He feels that LID should be promoted in both new developments and retrofitting.

Thomas Hengelsberg -- South Burlington, VT
Dore and Whittier, Inc.

Tom is a practicing architect whose portfolio includes the Heritage Aviation facility. He is very familiar with Act 250 and LID in architecture, separating practices into passive and active systems. He has had firsthand experience with developers who complain about the cost and unpredictability of stormwater permitting. He is in favor of a flowchart to facilitate the permitting process.

Jeff Hodgson -- Burlington, VT
H. Keith Wagner Partnership

Jeff is a practicing landscape architect who has been working with LID for the majority of the past decade. He understands the cost and schedule constraints of clients that compete with LID implementation and permitting. He is a strong proponent of the professional credit system, stating a constant need for educational credits from whatever source. He believes that, in order for LID to become popularly used, the state needs to shift its landscape aesthetic mentality away from traditional conceptions of outdoor space.

A.4 Stormwater and LID Education Sources

Neiswender, Catherine and Robin Shepard. “Elements of successful stormwater outreach and education.” Proc. of National Conference on Urban Stormwater: Enhancing Programs at the Local Level, February 17-20, 2003. Chicago, IL: U.S. Environmental Protection Agency

The presentation of this study at an EPA conference in 2003 shared aspects of successful education and outreach programs in the Midwest. The program delivers information despite turnover in leadership within the states, builds community support, identifies goals and target audience, and creates a network of educational programs.

The study also noted that regulation and enforcement must be coupled with education to reach the goals, especially in situations which lack enforcement and penalties and deal with a large audience. The most important point of this paper was the focus on outcomes-based education. This style of education depends on programs based on local values that use knowledge and research in decision making and focus on the desired outcome. This style shifts the focus toward changes in behavior, not just immediate output of a program. They used this style of teaching in their projects and considered it highly effective.

Smart Waterways. Chittenden County Regional Stormwater Education Program, 2010. Web. <http://www.smartwaterways.org/>.

Smart Waterways is a resource from the Chittenden County Regional Stormwater Education Program (RSEP). The program is part of the public education effort required by the EPA under the agency’s storm water system permits. This site is geared toward regular citizens and divided into 5 different sections: Auto Care, Excess Stormwater, Home Improvements, Pet Waste and Soil and Lawn Care. Each section addresses problems and provides simple, basic “tips”. The RESP breaks down the issue of stormwater into simple practices that one can incorporate into everyday life.

"Stormwater Education Toolkit." *UCF Stormwater Management Academy*. College of Engineering and Computer Science at UCF, 2002. Web. <http://www.stormwater.ucf.edu/toolkit/>.

The Stormwater Education Toolkit (SET), created by the Florida Department of Environmental Protection Bureau of Watershed Management and the Stormwater Management Academy at the University of Central Florida, through funding from the EPA, is a collection of stormwater education materials. The SET is divided into three volumes: General Public, Business/Industry & Government and Youth. Each volume is then divided into subcategories that focus on specific themes, such as Lawn & Garden, Low Impact Development, Stormwater Runoff and Water Conservation. This database is expansive and an excellent resource for anyone who is starting a stormwater education program. This site has the best assortment of materials for educating professionals in business and industry.

"Stormwater Outreach Materials and Reference Documents." *US Environmental Protection Agency*. Office of Wastewater Management, 2009. Web. <http://cfpub.epa.gov/npdes/stormwatermonth.cfm>.

The EPA materials are listed on their National Pollutant Discharge Elimination System (NPDES) website, as "Stormwater Outreach Materials." This site includes materials for the general public, contractors, landscapers, homeowners and children. This site also provides fact sheets about revolving funds and how to go about funding these initiatives. The majority of the materials can be customized with information that is relevant on a local scale, and their availability lifts some of the burden of creating new educational materials for each county or municipality in the state of Vermont.

Chesapeake Bay Stormwater Training Partnership. 2010. Web. <http://www.cbstp.org/>.

The Chesapeake Bay Stormwater Training Partnership is a strong model of a stormwater education program. The program offers different levels of training, from basic knowledge about stormwater management to training about Best Management Practices (BMPs) and structural and non-structural practices. It also offers courses in a variety of forms including workshops, webcasts provided by a broad range of guest speakers, on-site assistance and web-based training, which includes webcasts, presentation materials and training modules. The program has the noble goal of educating the public, but this informational website will not reach many people, and those who do find it while surfing the internet are likely to be people who already have knowledge about stormwater, or at the very least have an interest in environmental stewardship.

"Lake Champlain Basin Program: Education and Outreach." *Lake Champlain Basin Program*. Web. 22 Nov. 2011. <http://www.lcbp.org/educsum.htm>.

A local, relevant resource of stormwater education materials for Vermonters, the Lake Champlain Basin Program provides elements for educators, children and the general public. The "Lake-Friendly Tips" are an effective public resource that gives a list of easy, accessible tasks that the public can act upon. LCBP holds workshops for educators, school and other community groups. The resources and workshops for educators provide unique means of creating more individuals who are able to educate others about stormwater runoff.

Chapter 3 Vermont Runoff Management Utility (VRMU)

Paul Hildebrand, Becca Fanning, Yuan Lim

Executive Summary

The Vermont Runoff Management Utility (VRMU) proposal is focused on providing solutions to stormwater runoff management issues across the entire state. The proposal draws from existing utilities and fee systems both in and out of the state to establish a reasonable and sound methodology for a statewide system.

At present, two runoff management utilities exist in the state of Vermont. They are located in the cities of Burlington and South Burlington. This statewide proposal suggests that Vermont form the nation's first statewide runoff management utility in an attempt to both mitigate flood damage and to reduce water pollution statewide. A statewide utility provides several advantages over existing municipal utilities in Vermont. Cost-effectiveness is the primary advantage of a statewide utility, because experts can redistribute funding to areas (such as agricultural lands located next to waterways) where most effective runoff mitigation can take place. In addition, a statewide utility will see significant economies of scale, more regular and efficient permitting, and greater potential for large capital projects than a network of municipal utilities. Finally, a statewide utility can better address issues of agricultural runoff at minimal cost to agricultural landowners.

The proposed utility will collect an estimated $22.9 million of annual revenue through property tax bills. This tax will consist of a flat fee charge for residential properties and a proportional fee for commercial, industrial, agricultural, and municipal properties based on total impervious surface area.

The money collected will be spent on improvement projects aimed at urban runoff mitigation, localized flood control, and agricultural runoff reduction. These projects will include new low impact development (LID) infrastructure, retrofits, and riparian buffers. Utility managers will divide funds between staffing, equipment, and a state stormwater education program. Improvement projects will be selected based on cost-effectiveness, as determined by a robust system of GIS and computer modeling paired with local scale monitoring.

The proposal also includes an opt-in revenue sharing program called GrassRoots. Towns will have the option to receive 20% of fees they collect to implement autonomous runoff mitigation projects. Concurrently, a revolving loan fund will be set up to provide zero or negative interest rate loans that will incentivize local project implementation. Towns and property owners will use the shared revenue to pay back loans, reducing the need for external funding or debt.

A proposal such as this inevitably faces a series of difficult issues including the integration with existing utilities in Burlington and South Burlington, the role of agriculture in runoff mitigation, political challenges such as the perception of the fee as taxation, issues of equity, and cost-effectiveness. However, the benefits gained from a statewide utility far outweigh the short-term costs to property owners. The GrassRoots program also helps to ensure that the distribution of funding from the VRMU does not neglect small towns.

At present, Vermont is well situated to become the first state to implement a statewide runoff management utility, and in the wake of damages from Tropical Storm Irene, public demand for such a utility is growing. A statewide runoff management utility will allow Vermont to make significant investments in both flood mitigation and waterway ecosystem health at a minimal cost to its citizens. Use of the term runoff, instead of stormwater, is intentional, as mitigation measures taken by the utility will address all forms of runoff that contribute to pollution and flood damage.

Key Terms and Acronyms

Stormwater Runoff – Stormwater runoff occurs when precipitation from rain or snowmelt flows over the ground. Impervious surfaces like driveways, sidewalks, and streets prevent stormwater runoff from naturally soaking into the ground (EPA).

Stormwater Utility – Utility structure that manages stormwater mitigation initiatives, funded by a dedicated recurring fee charged to residents.

LID – Low Impact Development: A development or re-development practice that works with nature to manage stormwater as close to its source as possible (EPA). Also known as green infrastructure.

ISU – Impervious Surface Unit: 1000 square feet of area that blocks the infiltration of water through the ground, the growth of plants, or filtration of pollutants (i.e. parking lots, rooftops, and other paved areas).

ERU – Equivalent Residential Unit: Most commonly used as a unit of measure in stormwater utilities nationwide to equate runoff of non-residential or multi-family residential water usage to a specific number of single-family residences (i.e. one ERU equals the runoff generated by a single-family residence).

MS4 – Municipal Separate Storm Sewer System: publicly owned conveyance or system of conveyances (i.e. storm drains, pipes, and ditches) designed or used to collect and convey stormwater to surface waters of the State.

TMDL –Total Maximum Daily Load: calculation of the maximum amount of a pollutant that a water body can receive and still safely meet water quality standards (EPA).

3.1 **Background: Stormwater Utilities**

3.1.1 What is the Problem?

As the population increases, development puts pressure on stormwater treatment systems. Increased impervious surface leads to an increase in the volume and intensity of stormwater runoff, and consequently an increase in the volume of pollutants running into major waterways. Nonpoint runoff from all land use types, such as agricultural land, developed land, and forested land is difficult to manage, regulate, or control. However, the effect of phosphorus loading on state rivers and lakes is difficult to ignore. As state waterways fall into poor health, and pose a danger to people and animals, the issue becomes more pressing than ever. An additional problem is flooding: as Tropical Storm Irene demonstrated, Vermont is ill-prepared to deal with flooding at an urban level. Although flood damage from high river levels is very difficult to prevent, little is being done to mitigate localized flooding in Vermont towns.

Phosphorus concentrations in Lake Champlain are higher than allowed by Vermont's Water Quality Standards and hence must be managed by a Total Maximum Daily Load standard. This measurement is the maximum amount of a single pollutant that can exist in a water body before it is considered polluted. Nutrients like phosphorus facilitate plant growth even in an aquatic environment. High levels of phosphorus lead to huge algal blooms that take over a river or lake in a process called eutrophication. As they grow, the blooms block sunlight from reaching the deeper areas. When they die these plants absorb dissolved oxygen that fish and other aquatic animals need to survive. In extreme cases blue-green algae (cyanobacteria) produces neurotoxins that are harmful to plants and animals and affect the entire food chain if consumed.

In 1972 The Environmental Protection Agency expanded The Clean Water Act to focus on pollution control across the United States. The act set water quality standards, banned point source

pollution, and established a National Pollutant Discharge Elimination System (NPDES) permit program to control discharges. The act effectively eliminated point source pollution from major waterways, yet did little to address nonpoint sources of pollution.

Modern stormwater systems must make management decisions with the interconnectivity of waterways in mind. They must address the volume of stormwater runoff, the pollutants that end up in major waterways, and their sources. In Vermont, runoff management has never been addressed on a statewide scale, and as a result, existing systems have failed to combat pollution sources that lie outside of the Burlington area. The Vermont Runoff Management Utility (VRMU) will address the problems at their source, and will attempt to find solutions that involve all communities and benefit the state as a whole.

3.1.2 Statewide Runoff Management Utility

A statewide runoff management utility is a comprehensive fee system that charges every taxpayer a monthly fee in order to deal with state runoff issues on a large scale. The fees are added to property owners' property tax bills and accumulate in one fund that can be used to manage stormwater in areas that need it most. Simply put, stormwater runoff crosses geographical and political borders, and so too must runoff management.

The statewide utility has several aims under the umbrella of improving water quality in Lake Champlain and surrounding waterways. First, the utility will unify pollution prevention and runoff management efforts. By addressing the interconnectivity of the state's waterways, planners put themselves at a considerable advantage against harsh pollutants. A statewide approach allows planners to stop pollutants at their source and acknowledge the transboundary nature of waterways. This approach works to eliminate the disjointed regulations of municipal utilities.

Second, the statewide system will work to promote awareness of the issues that plague Vermont's waterways. By unifying mitigation efforts and charging a fee to all Vermonters, solving the problem becomes a collective effort. Saving the lake should not be limited to those who live directly on its shores. A statewide runoff management utility will ensure that the biggest environmental issues that plague Vermont are managed efficiently and with long term preventative measures to ensure ecosystem health for years to come.

3.1.3 The Framework of Existing Utilities

Burlington

The Burlington branch of the Department of Public Works (DPW) implemented the Burlington Fee System in 2009 to address stormwater permit requirements across the city (City of Burlington, 2011). Under this system, residents of Burlington pay a small stormwater user fee in addition to their monthly water bill. The DPW uses funds collected to implement stormwater management practices that meet statewide standards.

In 2008 the city adopted city code Chapter 26 and began the subsequent Stormwater Project Review Process. Under this law the stormwater program must review all city projects that disturb more than 400 square feet of earth (City of Burlington, 2011). Landowners must complete a Small Erosion Prevention and Sediment Control Plan Form before undertaking any project of this size. The form outlines potential impacts of construction, and enlists the help of homeowners and contractors in green building practices. The DPW charges a fee and mandates regulations for projects on a case-by-case basis and is willing to work with individuals to design ideal management plans.

In addition to the permitting system, under the fee system, the DPW charges all properties with impervious surface such as driveways (both paved and unpaved), walkways, and rooftops. There is a monthly flat fee for single-family homes ($3), duplexes ($3), and triplexes ($3.60) based on a

calculated average of impervious surface on these property types. Owners of commercial space, seasonal homes, and vacant lots pay based on impervious surface units (ISU). One ISU is equal to one thousand square feet of impervious surface area and property owners pay $1.17 per ISU (City of Burlington, 2011).

In order to connect the problem with its solution, the DPW designed a credit system to provide financial incentives for runoff prevention installations. Up to 50% of fees can be excused with the existence or implementation of stormwater infrastructure. The May 2009 Credit Manual lists the possibilities for green infrastructure and alternative stormwater management. This system is currently only available to property owners charged by ISU. Residences subject to a flat fee are not yet eligible to receive credit.

Public outreach is another key aspect of the Burlington system. Burlington joined several other communities to form the Regional Stormwater Education Program. This regional partnership of local municipalities and MS4 partners works to plan and fund education outreach throughout the state. Coordinated by the Chittenden County Regional Planning Commission, the education system collects $5000 annually from each town or city to fund projects to promote awareness of stormwater problems and public involvement in their solutions. A variety of media including short television ads, posters, and airport displays have come from the project.

Projects and Funding

The city spends $200,000 annually to maintain infrastructure and manage stormwater throughout Burlington. According to the Burlington Department of Public Works, urban maintenance such as street sweeping and catch basin cleaning has become a huge financial burden on the city. There are not enough permitted dump sites, and standard tipping fees add up to over $90 per ton to privately owned landfills. One or two projects usually absorb $75,000 of the annual capital budget.

The Burlington system can also apply for outside funding to supplement the fee-based budget in order to undertake larger projects and initiatives. To date, the system has received capital grants from Green Mountain Power and the Environmental Protection Agency in order to restore Englsby Brook at the Burlington Country Club. The city has devoted two million dollars to the development of a watershed plan, trash cleanup, and the expansion of a stormwater treatment pond at the Burlington Country Club. The Lake Champlain Basin Program recently issued a grant to remove pollutants from the College Street storm drain system in downtown Burlington. The estimated budget to install an underground treatment system for College Street is between $200,000 and $300,000 (City of Burlington, 2011).

The Burlington system is an example of effective permitting and logical cause and effect planning. The fee system links user costs directly with user impacts, and works to return collected fees back to the areas that need them most (City of Burlington, 2011). The education system is one that should be expanded to reach all counties, and would have a place in a statewide runoff management utility. This fee structure is one that can be applied to all residential, commercial, and industrial land. However, large farm owners for example should not be expected to pay per Impervious Surface Unit on all agricultural fields (see page 3-20 for agricultural regulations). The Burlington funding structure could be expanded, and their grant system could succeed on a state level. The Burlington system is a valuable example of how to manage stormwater effectively and efficiently in Vermont.

South Burlington

The South Burlington Stormwater System is an example of a successful municipal runoff management system. The system was awarded an EPA Environmental Merit Award in 2008 for using "high quality operations, education, collaboration and cutting edge science to carry out an

outstanding program of system maintenance, capital project construction, customer outreach and assistance and enforcement" (EPA, 2008).

This utility receives all funding from monthly fees included in sewer and water bills. The fee is $4.50 for single-family residences. On other properties the fee is $0.15 per month per 1,000 sq. feet of impervious surface (one ISU). No developed properties are exempt from this fee and the City of South Burlington even pays fees for all roadways and municipal buildings. However, credits are available that can reduce stormwater fees by up to 50%. Three credit programs are currently in place:

- Stormwater Treatment Practice (STP) credits are available to properties that take accepted measures to reduce their stormwater impacts.
- Education credits are available to schools that take measures to educate students about stormwater issues.
- Municipal separate stormwater sewer system (MS4) credits are available for successful stormwater systems outside of the city network (i.e. University of Vermont).

The utility also leverages funding through a number of national, state, local, and nonprofit programs such as the Town Highway Structures Grant Program, the Safe, Accountable, Flexible and Efficient Transportation Equity Act (SAFETEA) grant program, and the Waterwheel Foundation. See Appendix A.1 for a complete list of funding sources.

The approximate total budget for the utility is $1.7 million annually. This money is used for stormwater system construction and maintenance, erosion and sediment control, and illicit discharge detection and elimination. Additionally, this money pays for engineering, design, watershed assessments, permit compliance, stormwater system inventory and inspection, and employment and operating costs. The utility currently maintains all stormwater systems in South Burlington. However, due to high costs of initial system upgrades in the first years of its existence, South Burlington currently spends over 20% of its total budget on interest from previous improvement

projects, and just over 15% of its budget on new improvement projects (South Burlington Stormwater System). A budget that allows more money for current projects would be preferable.

What can we learn from the South Burlington system? The system has been highly successful at leveraging funding from a variety of different sources, something that a state utility should seek to do for optimal efficacy. Runoff treatment provides many positive externalities in terms of water quality, infrastructure maintenance, and flood damage control. Every effort should be made in a state utility to leverage funding available to projects that achieve these objectives. While initially expensive, their fee structure is effective and fair. However, the funding source for this system (water and sewer bills) is not necessarily practical on a statewide scale because of the high number of VT residents not on a municipal water system.

Washington, DC

Beyond the existing stormwater utilities in Vermont (Burlington and South Burlington), several utility models exist around the United States. Washington D.C. provides a good example of an equivalent scale: Vermont and the District have a population of 625,000 and 605,000 respectively. The District of Columbia Department of the Environment (DDOE) holds responsibility for management of stormwater pollution in the District and currently charges commercial and residential property owners a stormwater fee based on the amount of impervious surface on each property (DDOE, 2010). Each Equivalent Residential Unit (ERU) is charged $2.67 per month. All other properties, such as businesses and large multi-family properties are charged $2.67 per month for each 1,000 square feet of impervious area on their lot, rounded down to the nearest 100 square feet.

Unlike the South Burlington and Burlington stormwater utilities, the D.C. scheme does not provide incentives for installation of green infrastructure or for creation of education programs. However,

the DDOE has proposed an update to the fee system to provide credits for properties that install practices that retain stormwater, such as rain gardens, rain barrels, and green roofs. The proposed scheme would offer up to a 55% discount depending on the size and scope of the project.

A critical issue remains in the rhetoric and management of the D.C. utility. The federal government in D.C. calls the fee a "tax" and hence avoids paying in to the system. As a sovereign entity, the federal government is immune to taxes. By skirting around the fee, the federal government does not contribute to stormwater mitigation in the city, and hence limits the effectiveness of the project. When implementing a statewide system, it is essential to use language and regulatory strategies that will equitably collect fees from the entire population, so that all residents are contributing to this common-good effort.

3.1.4 Why is a Statewide Utility Preferable to a Network of Local Utilities?

The first reason is efficiency. With a large-scale utility, economies of scale are inevitable due to decreased costs of staffing, engineering, equipment, etc. This frees up a larger percentage of funding for improvement projects. Also, as a utility scales up, more expertise is available to hold projects implemented to a higher standard. Finally, with a budget that allocates over $6,000,000 to improvement projects, large-scale (over $200,000) improvement projects are possible (see full budget in Appendix A.2).

The second reason is equity. With local utilities working to preserve watershed quality, questions of parity and equity inevitably arise. Why are one town's taxpayers paying fees that will benefit many other towns? Why are farms, which contribute significantly to water pollution, not adopting appropriate mitigation techniques at all? With waterways as a public good, towns are often reluctant to commit funding when other towns are doing nothing. A statewide utility helps address these issues of parity and ensures that all homeowners in Vermont are paying for cleaner waterways that

will benefit everyone. The statewide system ensures that each dollar does the most good in preserving water quality.

The third reason is consistency. A hodgepodge of different local utilities makes stormwater discharge reduction difficult for homeowners, business owners, and municipalities. Such a piecemeal system also complicates the permitting process. By creating a consistent statewide system, regulations will be clear, permitting will be simplified, and greater consistency and longevity can be ensured.

3.2 Vermont Runoff Management Utility Plan

3.2.1 Policy Background

i. Vermont Clean and Clear Program

The Vermont Clean and Clear Program (renamed the Ecosystem Restoration Program in 2010) begun in 2003 as a joint project between the Vermont Department of Environmental Conservation Water Quality Division, the Vermont Agency of Natural Resources, and the Vermont Agency of Agriculture. It was begun with the goal of reducing phosphorus pollution in Lake Champlain and reducing related pollutants in waters statewide. This project has helped leverage over $84 million dollars in efforts to reduce phosphorus loading below the Lake Champlain Phosphorus Total Maximum Daily Load (TMDL) levels. This money pays for projects in both rural and urban areas aimed at reducing phosphorus levels in runoff.

ii. Conservation Reserve Enhancement Program (CREP)

The Conservation Reserve Enhancement Program (CREP) is a 15 or 30-year joint state and federal contract with agricultural landowners to improve water quality in streams and lakes (Vermont Agency of Agriculture, 2008). They achieve this by establishing vegetative buffers (minimum 35 feet), which filter runoff by trapping sediment, fertilizers, and pesticides. Upfront incentive

payments and annual rental payments based on the total acreage dedicated to forested buffers or vegetative filter strips compensate landowners for loss of productive land. Federal cost-share and incentive payments can cover up to 100% of implementation costs. However, the CREP eligibility requirement of a minimum 35 foot riparian buffer may discourage agricultural landowners to remove such a significant strip of land from productive uses. Thus, the GrassRoots Program (see Section 3.2.2 - Basic Framework iii) will provide an alternative funding mechanism with greater flexibility and increased eligibility for vegetated riparian buffers.

iii. Wetland Reserve Program (WRP)

The Wetlands Reserve Program (WRP) in Vermont is a voluntary program run by USDA Natural Resources Conservation Service (NRCS) that offers landowners technical and financial assistance to protect, restore, and enhance wetlands on their property. In exchange, landowners will retire eligible agricultural land from production permanently or for 30 years. Fields that are frequently flooded or unproductive due to wet conditions are good candidates for WRP. The NRCS goal is to achieve the greatest wetland functions and values, along with optimum wildlife habitat, on every acre enrolled in the program. Therefore, while the WRP serves as an excellent program to retire unproductive land, it will exclude productive agricultural land located next to waterways with significant runoff in storm events. The proposed GrassRoots Program (refer to Section 3.2.2 , Basic Framework iii) will fund riparian buffers and vegetated strips on riparian areas that contribute significantly to runoff, regardless of land productivity and size.

3.2.2 Basic Framework

i. Who would operate the utility?

Contracted Third Party

The state will accept bids from a variety of third party contractors in order to decide the best fit for their purposes. The addition of a politically neutral manager helps to make a utility run smoothly (Hamilton, 2008). Following the model of Efficiency Vermont, which is privately contracted to a third party and is also overseen by a few state officials, the Vermont Runoff Management Utility (VRMU) will maintain some state control while mostly relying on third party contracts. The coordination between the two groups ensures that each decision is made with the state's best interest in mind, while simultaneously satisfying the public. Just as Efficiency Vermont provides technical advice, design guidance, and financial assistance to help make Vermont homes, farms, and businesses energy efficient, the VRMU will offer assistance with a variety of stormwater mitigation techniques and practices (Efficiency Vermont, 2011).

The third party will begin work under a performance-based, three-year contract to ensure the quality and efficiency of the utility. During the first years of implementation, the project will be limited in scope, and will serve as a baseline model and a useful way to measure progress in future years. Periodic check-ins will evaluate the managers based on a set of progress indicators such as town project numbers and success rates over time (See Section 3.2.4). If these standards are not being met, the state will reevaluate the third party management, and decide when to let the existing contract run out in favor of a new bidder. The indicators of progress ensure fairness and facilitate communication on both sides of the utility.

If after several evaluations, the third party performs up to standards, the state and third party will discuss the possibility of a franchise with a defined term. This is something that Efficiency Vermont has explored and would be beneficial to the project as a whole. This would provide more consistency and allow for long-term planning and avoid wasted resources on frequent bids.

ii. How would it be funded?

Income for VRMU will come from a system of monthly fees imposed on landowners, homeowners, businesses, and municipal structures. Homeowners will be charged a flat ($3.00 per month) stormwater fee for single-family homes and $1.50 per month per housing unit in all other residences (duplexes, townhouses, apartments, etc.) Nonresidential (commercial, industrial, and agricultural) and municipal land (including roads) will be charged $1.10 per month per Impervious Surface Unit (1,000 square feet of impervious surface). For agricultural lands, only roofs and paved areas will be considered impervious.

Supplemental funding for stormwater projects will be leveraged from a variety of other federal, state, local, and nongovernmental sources. South Burlington's Stormwater Utility has been extremely successful at leveraging funding from several other sources and there is no reason that a statewide utility cannot leverage the same funding. See Appendix A.1 for a list of all outside sources used by South Burlington for their improvement projects. Funding from these outside sources can be expected to provide an additional 40-60% on top of existing funding for improvement projects. It will be essential for the VRMU to dedicate the necessary time and research to fully take advantage of these programs.

Rebates

Green infrastructure (LID) Rebates will be available to all landowners who make investments to reduce runoff by implementing LID practices on-site. All residents, from single-family homeowners to agricultural landowners have the option of implementing such infrastructure. Rebates will amount to a 66.7% reduction in runoff fees for residences and a 50% reduction in fees for commercial, industrial, and municipal structures. Rebates will be granted based on the "Voluntary Stormwater Management Credits" outlined in Section 3 of the Vermont Stormwater Management Manual,

although this should be modified in the future to ensure ease of small-scale credits (i.e. on residential properties).

Similar to South Burlington, two other partial rebates will be made available to municipalities. Rebates of 75% of stormwater fees will be made available to schools (public and private) who implement a runoff management education program. Also, rebates of 50% will be available to existing, independent MS4 stormwater management systems (such as the one in place at the University of Vermont), provided their continued holding of MS4 Permits distributed by the Vermont Department of Environmental Conservation (VTDEC).

iii. What services would it provide?

Project Implementation

The utility will primarily focus on implementing LID construction, retrofits, or repairs on a statewide level. This will be divided into two sectors: a top-down, state-run program that focuses on the most cost-effective mitigation possible, and a GrassRoots small-scale stormwater program discussed below.

For the primary program, VRMU engineers will use GIS analysis, engineering studies, and other analytic methods to locate significant urban and rural runoff problem areas across the state. These engineers will then be charged with designing proposals to address these sources of runoff pollution by mitigating and/or filtering stormwater before it reaches waterways. Better runoff management will have the added benefit of reducing localized flooding. Although runoff mitigation technologies cannot defend against large-scale river flooding, technologies such as porous pavement and constructed wetlands can help mitigate localized flooding in urban areas, reducing damage (NRDC 2006). The primary objective of this program will be cost-effectiveness in improving the quality of waterways and the ability of towns to deal with floodwater.

Both urban runoff and agricultural runoff mitigation projects will be considered. Agricultural projects (such as riparian buffers) can create significant reductions in stormwater runoff impacts. However, farmers often lack adequate capital or incentive to develop these projects themselves. The VRMU's legal team will work with farmers to determine equitable solutions that reduce water pollution and runoff with minimal financial burden to farmers.

Operations & Maintenance

Projects will be designed to have minimal or zero operations and maintenance costs. For example, a large rain garden or constructed wetland should be designed to be self-sustaining. For state-funded improvement projects, operations and maintenance will be the responsibility of the property owner or municipality. However, the statewide utility will offer a free, three-year warranty and maintenance plan for all projects. Any operations and maintenance charges within three years of the date that construction is completed will be covered by the VRMU. After three years, responsibility for operations and maintenance will be transferred to the landowner. Improper maintenance by the landowner will result in fines, and monitoring teams will periodically check on projects to monitor their continued performance. However, in cases where a project experiences significant damage (e.g. after a hurricane), towns will be able to apply for GrassRoots funds for refurbishment (see below).

The VRMU will not be responsible for the operations and maintenance of existing runoff management infrastructure. This will remain in the hands of the towns that currently maintain it. However, as discussed, upgrades or retrofits to this infrastructure will be eligible for funding from the GrassRoots program.

GrassRoots Program: An Opt-in Revenue-Sharing Model and Revolving Loan Fund

The GrassRoots program is a key initiative of the budget proposal to provide equity. This program aims to promote smaller-scale, bottom-up runoff mitigation projects. It is designed to raise

awareness of green infrastructure at the town level and to give property owners agency over the money that they contribute to the stormwater fund. First, towns are entitled to a 20% share of the utility fee they collect on an opt-in basis. The opt-in process is contingent on a proposal for runoff mitigation that can include basic services like street sweeping or specific runoff mitigation projects like retention ponds. Shared revenue from runoff utility fees will fund accepted town runoff mitigation proposals. As a result of the opt-in model, towns that do not wish to submit runoff mitigation proposals will not be required to act. Their share of the utility fee revenue will remain with the utility for statewide projects.

An engineering team at the VRMU will evaluate the proposals from towns that opt-in. Project proposals can apply to municipal, commercial, industrial/agricultural, or residential land, though projects on non-municipal land will require significant contributions from property owners. Towns who submit an approved plan will then receive shared revenue equal to 20% of total payments from citizens, businesses, and municipal lands in their town to fund the project.

The second component of the GrassRoots program is a revolving loan fund (RLF) that provides loans at zero or negative interest rates. The fund allows towns and municipalities to construct green infrastructure (LID) projects beyond their annual shared revenue, with a loan payback period of up to 8 years. Moreover, the negative interest rate shall be used to provide incentives for certain projects such as agricultural buffers. The revolving loan fund will be capitalized in the first year of operation by setting aside $1 million from utility fee income.

The following illustrates two examples, with zero and negative interest rates respectively. Town A is eligible for yearly shared revenue of $20,000 and applies for a $100,000 loan from the GrassRoots RLF to construct a retention pond. Under the zero interest rate plan Town A will pay back the loan in $20,000 installments for 5 years via their annual shared revenue. Town B is also eligible for annual

shared revenue of $20,000 and applies for a $100,000 loan to construct agricultural buffers. Under the negative interest rate plan of -5% for farm buffers, Town B will hence pay the loan in $19,000 installments for 5 years (total of $95,000, or 95% of the initial loan amount).

Technical Advisory Teams

Dedicated technical advisory teams, similar to the Vermont Better Backroads Program, will be comprised of engineers and experts on runoff management. These teams form a crucial part of the statewide utility's goal to provide technical assistance to resource-poor municipalities and towns. They will mainly provide consulting and technical advice on project implementation, especially to rural communities with no town planner or engineers. Moreover, these teams represent a dedicated resource for runoff mitigation projects, unlike current town planners and public works programs that serve multiple functions. The formation of such teams ensures equity and access to advice beyond what small towns can afford.

State Stormwater Education Program

Current regional and decentralized efforts in stormwater education will be unified in a State Stormwater Education Program. The education program will receive a dedicated portion of utility fees collected, and will use them to subsidize school educational materials and faculty training, community outreach events, conventional media such as print and television advertisements, and even new media such as social networking sites and online interactive content. As a main advantage of the state education program, schools will face reduced costs in devising lesson plans and materials. Moreover, towns will benefit in the form of Stormwater Education Toolkits designed for specific interest groups (i.e. homeowners, businesses, industries).

Low Impact Development Design Competition

One idea to help the VRMU gain positive publicity and to educate the public about stormwater runoff during its phase-in period is an LID design contest (called the GrassRoots Stormwater Design Contest). This contest would use money from the first year's budget to publicize, design, and judge a contest in which the utility would fund the winning design.

The contest would be open to anyone: municipalities, businesses, homeowners, etc. They would be given a target budget (e.g. $250,000) and asked to design an effective, innovative, and aesthetic stormwater project for this target budget. VRMU's team of engineers would judge proposals and although one winner could be selected, alternative projects would also be submitted to engineers as part of the GrassRoots program.

iv. Relationship with Agriculture

Farms and other agricultural lands will be charged based on roof and paved space only. By eliminating the impervious surface charge on fields, some of the financial pressure felt by farmers will be alleviated. Agricultural land will be charged $1.10 per Impervious Surface Unit (ISU), the same rate as businesses and municipal structures. In order to maintain a positive and productive relationship with farms, the utility will provide a 5% negative interest loan to encourage farms to implement projects. Agriculture continues to be an important part of the Vermont economy. Addressing the struggles of Vermont farms and working to soften the blow that a stormwater fee will impose ensures a continued relationship with farm owners and paves the way for more collaboration between the utility and the agricultural sector.

3.2.3 Relationship Between VRMU and Existing Utilities

Western Kentucky University's annual stormwater utility survey reveals the rapidly increasing number of stormwater utilities nationwide (Campbell, 2008). They tend to cluster based on weather

patterns, development, and funding. However, the "cluster effect" also indicates how proximity to established utilities can increase a utility's acceptance and attractiveness. Thus, the existence of two current stormwater utilities in South Burlington and Burlington will show what utilities can achieve and offer for Vermont's runoff management needs. This plan proposes to integrate the two exiting utilities into the statewide entity, such that all Vermont residents pay one fee. An alternative plan (discussed in Section 3.3.1) will keep the existing utilities as separate entities, and thus charge Burlington and South Burlington residents a hybrid fee (same fee for existing utilities and lower fee for the statewide utility). All other Vermont residents will pay a single fee.

1. *Collection of Runoff Utility Fee by Property Tax*
    a) At present, South Burlington collects the stormwater fee through monthly water and sewer bills. Similarly, Burlington collects their non-traditional utility fee through water and wastewater bills.
    b) Only an estimated 50% of Vermont households pay water and sewage bills. Households in rural areas rely on wells for water and septic tanks to treat waste.
    c) To ensure collection of fees from all properties, the runoff utility fee is to be added to property tax bills. Hence, even vacant homes would not be exempt.
    d) As property taxes are collected by towns and sent to the state, towns shall collect 1% of the fee as administrative cost.
2. *Unify or Expand Existing Credits System*
    a) South Burlington currently grants credits for Stormwater Treatment Practices (STP), Education, and MS4 credits. Similarly, Burlington issues credits up to 50% of the fee collected.
    b) To maintain the incentive for individual runoff management, property owners who currently qualify for credits will continue to obtain recognition for their STPs, Education, MS4 credits, etc.
    c) However, in order to streamline paperwork and ensure fairness, a unified system of credits will be implemented to include both current credit systems. The credit will be capped at 50% for the initial phase of integration to ensure a minimum income for the utility. The credit ceiling may be raised in subsequent years, pending evaluation of financial sustainability of the utility.
    d) Consequently, a credit trading system, similar to carbon trading may be proposed in the future to encourage larger runoff management projects and innovation.
3. *Maintain Grant Systems*
    a) At present, South Burlington successfully leverages funding through a number of national, state, local, and nonprofit programs. Similarly, Burlington receives grants from the EPA and Green Mountain Power.

b) Thus, the current system of grant application and recipients shall remain unchanged. The utility (state projects) or local authorities (municipal or county projects) will make the application for grants with regard to runoff management projects.
c) A central grant database shall be established and managed by the utility in order to maximize grant leverage by providing equal access and streamlining applications.

4. *Create City Management Teams for SBSU and BSU*

a) Burlington and South Burlington have implemented stormwater management projects and treatment plants. Currently, SBSU maintains and is responsible for projects completed.
b) To ensure smooth continuation and maintenance of current and past projects, the utility shall create dedicated city runoff management teams for the cities of Burlington and South Burlington. The initial staff shall be drawn from the existing utilities.
c) Control and long term management of qualifying projects shall be gradually relinquished to the teams.
d) Large scale projects such as runoff treatment plants shall continue to be managed by the utility.

5. *NPDES Permit Compliance Assistance*

a) At present, South Burlington devotes significant resources to stormwater permit compliance. Municipalities, industries, and new development also encounter high barriers to permit compliance.
b) The state runoff management utility shall provide assistance in permit compliance, which may include training seminars and workshops that aim to reduce long term compliance costs.

6. *Incentive System for Good Zoning*

a) In 2009, 29 out of 136 towns in the Lake Champlain Basin (~20%) possessed good water quality protections standards in their zoning laws (VANR, 2009).
b) Thus, an incentive system for good water quality protection zoning shall be established. Small municipalities who maintain good zoning will thereby receive a larger amount of shared revenue from the GrassRoots program.
c) The incentive must be structured above a town's existing runoff management budget to be attractive. In addition, a tiered system of rebates, corresponding to differing levels of town actions shall be established to encourage other municipalities to action.

7. *Education Programs*

a) At present, Burlington and South Burlington join several communities to form the Chittenden County Regional Stormwater Education Program. The program represents a regional partnership of local municipalities and non-traditional MS4 partners. A variety of media including short television ads, posters, and airport displays have come from the project.
b) The utility shall seek to support and expand the Regional Stormwater Education Program in its initial phase. Consequently, it may establish a unified Vermont Stormwater Education Program to replace the former.

3.2.4 Indicators of Progress

Indicators of a Successful Management Program

In order to evaluate the contracted third party and to insure uniformity in evaluations each year, a series of success indicators will be applied to the program. These indicators will be reviewed periodically. This method was used in the Vermont Clean and Clear Project, and works to compare progress, identify problems, and make changes to the developing utility or project. A series of baseline projects will be evaluated, with the hope that as the utility grows, these projects will see an obvious increase.

1. Town projects

Evaluate the number of projects proposed by towns in Vermont. This will measure the interest levels of towns, and hence track the success of education, and subsequently, action around the state. In the first year fewer projects are expected, as education will be a priority. However over time it is expected that the number of town projects will increase.

2. Grant applications

Regardless of approval rates, the number of grant applications tracks interest in the utility, and attempts at stormwater mitigation. More applications mean a higher quality of accepted projects, so this number cannot be high enough.

3. Municipalities that receive technical assistance with implementation

The need for technical assistance is directly connected with the scope of a project, and hence more technical assistance indicates a higher level of excitement for and interest in modern low impact development technologies.

4. Projects in a productive state after one year

This number reports the success rate of maintenance as well as effective implementation. If many projects are being installed, yet are not productive after the first year, the managers must re-evaluate implementation and maintenance practices.

5. Participants in seminars or workshops

Public interest is indicative of successful advertising as well as potential for expansion. The number of people who attend voluntary runoff management seminars and workshops proves interest and concern over the issue. Increasing public interest could also help validate grant proposals, affirm political favorability, and emphasize the need for more funding.

6. Towns with good zoning laws

As mentioned in the relationship with existing utilities, 29 out of 136 towns in the Lake Champlain Basin (~20%) possessed good water quality protections standards in their zoning laws. An increase in towns with good zoning laws will be evidence of the utility's efforts to provide incentives for towns to achieve good zoning practices. Achieving good zoning laws in all towns will serve as the long-term objective of the utility.

7. *Areas of treated projects*

In Philadelphia, the Greened Acre Project sets a goal to convert 9500 impervious acres to green space within the city (Green 2015). Such goal setting encourages community action and works to establish a sense of productivity on large projects. The utility must first examine how much area is treated now, in order to set future goals for treatment.

3.3 Further Questions to Address

3.3.1 Integration with Existing Utilities

To enact a statewide runoff management utility, two options exist for the present utilities in South Burlington and Burlington. First, the two existing utilities will integrate into the new statewide utility, leaving small, dedicated teams to operate and maintain past projects (as discussed in Section 3.2.3). The second option will leave the existing utilities to operate independently of the new utility. While most Vermont residents will pay a single fee to the new statewide utility, South Burlington and Burlington residents will have to pay a new reduced fee in addition to the existing fees they already pay.

The first option of integration will appear more equitable as all Vermont residents need only to pay one fee for runoff management. However, the new utility will have to take on substantial debts and maintenance of past projects, thereby limiting the use of funds for new projects. Also, the cities of Burlington and South Burlington could face difficulty fulfilling legal obligations to manage runoff if the statewide utility allocates insufficient funding to them. Thus, the second option will avoid the complexities of integration and the burden of managing past projects and debts. However, this will effectively charge South Burlington and Burlington residents twice for runoff management, calling into question the fairness of the system.

3.3.2 Governmental vs. Third Party Management

While this proposal focuses on a utility run by a third party, a state-run utility remains a viable option. Implementation through the state government eliminates the need for bidding or contracting. Alleviation of these concerns would free up time, money, and personnel for more important projects focused on the utility's goal.

However, the political feasibility of a government-run system is unclear. The idea of a growing state government is unpopular in the public eye, and the political pressure to undertake certain projects may take away from the productivity or focus of the utility. The state government is admittedly biased, and by putting government support behind an added fee could be detrimental to the project's progress and the utility's acceptance in smaller communities.

3.3.3 Role of Agriculture in Runoff Mitigation

Agricultural runoff contributes a significant amount to waterway pollution, especially in the form of phosphorus loading. However, at the same time, many farms lack the capital to invest in runoff mitigation techniques (such as riparian buffers) that could significantly decrease runoff, benefiting both the farmer and the watershed (NRC 2008). The structure of our stormwater utility allows for significant amounts of collected revenue to go to runoff mitigation projects on agricultural lands. If efforts to curb agricultural runoff prove to be cost-effective in reducing runoff and water pollution, then the stormwater utility can help Vermont make significant progress in a short period of time.

However, a handful of issues will have to be addressed for successful mitigation techniques to be installed and maintained. First, the VRMU will need to make specific outreach efforts to farmers about agriculture-specific runoff issues and the problems with phosphorus loading and water pollution in general. Second, a fair system of working with farmers must be negotiated: farmers may need to give up a small portion of land or perhaps adjust their farming techniques to make the project effective. However, farmers should be fairly compensated for any loss of productivity (if any) at the cost of runoff mitigation. This also raises issues of equity that will be discussed in the next section.

3.3.4 Issues of Equity

One of the most significant anticipated political hurdles in implementing the VRMU will be demonstrating that VRMU money is going into projects that will benefit all Vermonters. While part of this will need to be integrated with the education component (perhaps a brief annual report can be mailed with the tax bill), it is important to show taxpayers firsthand the benefits of the runoff management system. As such, it will be necessary to spread out projects geographically throughout the state. The GrassRoots program is an attempt to achieve this, but there may be more effective ways to do this. One proposed method would be to stratify revenue not by town but by land use type (residential/commercial/industrial/agricultural/municipal). Money collected could then go toward projects in that stratum, ensuring that residential money benefits residential areas, etc. We believe that our GrassRoots program is the best solution to this, but recognize that making the successes of this program apparent to all will be a continuing challenge.

3.4 Conclusion

Proposal for a feasibility study

This proposal is based on a solid foundation of knowledge, but more analysis will be necessary before the actual implementation of such a utility. The list below contains some but certainly not all necessary tasks and research that must take place before a bill comes before the Vermont legislature. A feasibility study encompassing these and more issues should be carried out as soon as possible.

Intensive meetings with officials from existing utilities

The cooperation and support of stormwater officials from the stormwater utilities in Burlington and South Burlington is essential. These meetings should be focused on learning from the successes and the failures of these utilities.

Town meetings

Discussions with the public and gathering public opinion will be an important part of phasing in a utility such as this one. Allowing for a public comment period decreases the chance for major public dissent or a lawsuit and could help bring fresh ideas to the utility.

A more complete budget

Experts should be consulted to create two budgets for the VRMU: an initial rollout budget and a medium-term operating budget like the one included in this report (Appendix A.2).

More accurate GIS modeling

The GIS map included in the introduction, for example, provides a rough idea of how much impervious surface exists in Vermont and where it is located. However, more detailed GIS analyses will be needed to determine where the most effective projects might be located and to improve the accuracy of estimates of income from fees for commercial/industrial/municipal properties. Similar maps and analyses could be completed for all land use types.

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Appendix

A.1 South Burlington Stormwater Utility Outside Grant Sources

- Local
  - Champlain Water District
  - City of South Burlington
- State
  - Vermont Better Back Roads Grant Program
  - Vermont Agency of Transportation Enhancement Grant
  - Town Highway Structures Grant Program
  - Vermont Department of Environmental Conservation Section 319 & Watershed Improvement Grant
  - Vermont Agency of Transportation Bridge & Culvert Grant
- National
  - SAFETEA grant
  - National Fish and Wildlife Foundation EPA 5 Star
  - EPA National Demonstration Project Grant
  - EPA Region 1 Special Funding to UVM
  - USDA Natural Resources Conservation Service
  - EPA State and Tribal Assistance Grants (STAG)
  - American Reinvestment and Recovery Act (ARRA)
- NGOs
  - Waterwheel Foundation
  - Lintillhac Foundation
- Local/State/National orgs
  - Lake Champlain Basin Program
  - Harbor Heights Homeowners Association
  - Quarry Ridge Homeowners Association
  - Indian Creek Homeowner's Association
  - Ridgewood Homeowner's Association
  - Twin Oaks Homeowners Association
  - Winding Brook Homeowners Association
- Companies
  - Shearer Chevrolet
- Labor grants
  - Vermont Commons School of South Burlington
  - Vermont Youth Conservation Corps

A.2 Proposed Budget

Tables A and B show a very rough preliminary estimate of revenue and expenditures for the VRMU. This is intended to illustrate a potential operating budget 3-5 years into the program; start-up costs will make the budget for the first two years substantially different. Our suggestion is to spend the majority of funding from the first two years on start-up costs and a few showcase projects to avoid significant debt that would hinder the medium-term growth of the utility. Looking at the South Burlington budget, much of their funding is currently allocated to paying off debt from large upfront projects and equipment costs at the outset of the utility. For the statewide utility, by having a budget well above $20M per year, we will be able to get started without amassing large debt payments.

The VRMU budget proposal was developed based on the South Burlington Stormwater Utility model. The budget illustrates the anticipated economies of scale from expanding to a statewide system; operating expenses and personnel expenses are expected to decrease as a portion of total expenditure as we transition a more efficient statewide system. The budget also anticipates less of the budget going to loan repayments (see previous paragraphs), as well as operations and maintenance.

A feasibility study should include a more detailed proposed budget, including a specific personnel structure and list of initial capital expenses (e.g. equipment, vehicles, facilities, etc.).

A: Proposed Budget - Income

	Monthly fees:	Units in VT:	Total income
Residential			
Single family homes	$3.00	250,375	$751,125.00
Multi-unit	$1.50	73,000	$109,500.00
Commercial/Industrial/Municipal			
ISU (1,000 sq. ft)	$1.10	952,800	$1,048,080.00
Total		**monthly**	$1,908,705.00
		yearly	$22,904,460.00

B: Proposed Budget: Expenditures

Category	VRMU	Pct.	S. Burl.	Pct.
Personnel expenses	**$3,503,537**	**16.10%**	**$499,685**	**31.08%**
Salaries	$2,393,721	11.00%	$333,083	20.72%
FICA/Medicare	$152,328	0.70%	$23,308	1.45%
Insurance	$609,311	2.80%	$85,218	5.30%
Pension	$304,655	1.40%	$45,143	2.81%
Other	$43,522	0.20%	$12,933	0.80%
Operating expenses	**$1,827,932**	**8.40%**	**$296,424**	**18.44%**
Office expenses	$65,283	0.30%	$32,300	2.01%
Vehicles/equipment	$217,611	1.00%	$21,000	1.31%
Insurance	$391,700	1.80%	$38,624	2.40%
O&M	$108,806	0.50%	$51,500	3.20%
Engineering Services	$174,089	0.80%	$51,000	3.17%
Public Outreach	$217,611	1.00%	$6,000	0.37%
Billing Services	$217,611	1.00%	$30,000	1.87%
Legal Services	$217,611	1.00%	$20,000	1.24%
Other	$217,611	1.00%	$45,500	2.83%
Capital Expenses	**$15,657,111**	**71.95%**	**$710,660**	**44.20%**
Improvement Projects	$14,677,862	67.45%	$256,042	15.93%
GrassRoots Program	*$4,352,220*	*20.00%*		
State Capital Projects	*$10,325,642*	*47.45%*		
Capital Projects - Interest	$435,222	2.00%	$331,899	20.64%
Vehicles & Equipment	$544,028	2.50%	$48,600	3.02%
Capital Equipment - Interest	$0	0.00%	$74,119	4.61%
Transfers	**$0**		**$100,000**	**6.22%**
Amortized Utility Development Costs	$0		$100,000	6.22%
Rebates	**$772,404**	**3.55%**		
Households (10% adoption)	$600,900	2.76%		
Comm/Ind/Trans (10% adoption)	$171,504	0.79%		
Total	**$21,761,100**	**100.00%**	**1,607,770**	**99.94%**

Chapter 4 Conclusion

As discussed in the introduction, Vermont has a serious and urgent stormwater problem. Many areas of Lake Champlain are in decline, compromising Vermont's ecological and economic health. This is primarily due to nonpoint source pollution, which is responsible for 90% of damaging water pollution nationwide (Huang et al 2007). Clearly, Vermont needs to develop a sustainable plan for stormwater if it wishes to maintain healthy waterways.

Our three projects addressed three of the issues that Vermont faces in developing a sustainable stormwater future. The first group addressed the importance of determining the composition of nonpoint source pollution. They developed a simple, affordable stormwater monitoring system for Middlebury that would also be applicable to other small towns. The second group studied low impact development (LID) technology in Vermont and the barriers to its implementation. They proposed programs to enhance the visibility of LID and facilitate its implementation in the private realm. The third group addressed the issue of collecting public funding to support the expansion of LID and stormwater mitigation statewide. They created a proposal for a statewide runoff management utility that would use tax revenue to fund a diversity of projects aimed at mitigating stormwater and runoff across the state.

There is still much work to be done. For many individuals, stormwater remains an issue of low importance. Robust public outreach efforts across the state will raise the profile of stormwater as a vital issue in Vermont. Such work will contribute to all three of our projects: it will encourage small towns to adopt monitoring programs, encourage private landowners to implement LID technology, and raise public acceptance of a statewide utility. Policy action is also necessary to push stormwater forward as a statewide priority; towns should implement monitoring programs, changes in legislation

should make LID more feasible in the private sector, and the legislature should carry out a feasibility study of a statewide utility.

Vermont is in a perfect position to become a national leader in stormwater management. With its wet climate and history of environmental leadership, Vermont is in a prime position to take decisive action on stormwater and nonpoint source pollution. Our research is a first step toward implementing solutions for Vermont's stormwater future.

Stormwater Outfall Pipe, Merchants Row, Middlebury, VT. *Photo: Kathy Morse*